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CONTENTS

ORIGINAL PAPERS

Are Meaningful Night Vision Tests for Drivers Feasible?
Ingeborg Schmidt 295

EDITORIAL

Contact Lenses Do Not Belong in the Market Place.
Monroe J. Hirsch 349

TRANSACTIONS OF THE ACADEMY

The Academy and Its Program.
Stephen C. Outlaw 351

Michigan Chapter Meeting at East Lansing.
Paul L. Connolly 357

CORRESPONDENCE

Contact Lenses at Body Temperature.
W. Burnley Stephens 358

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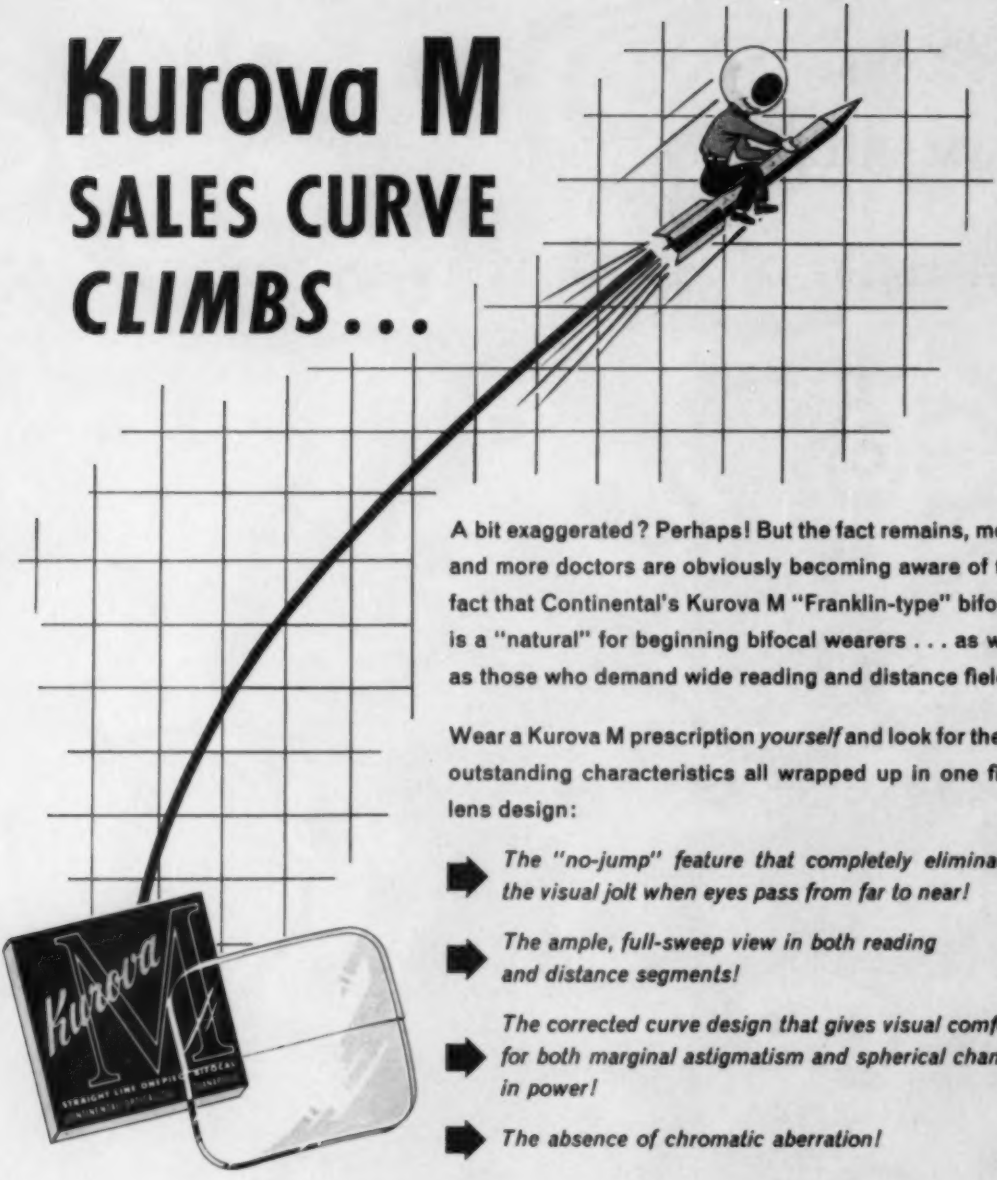

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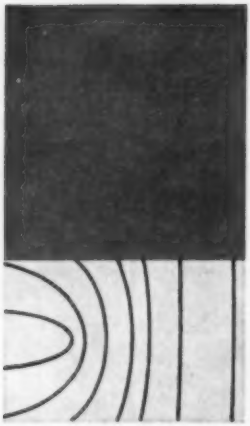

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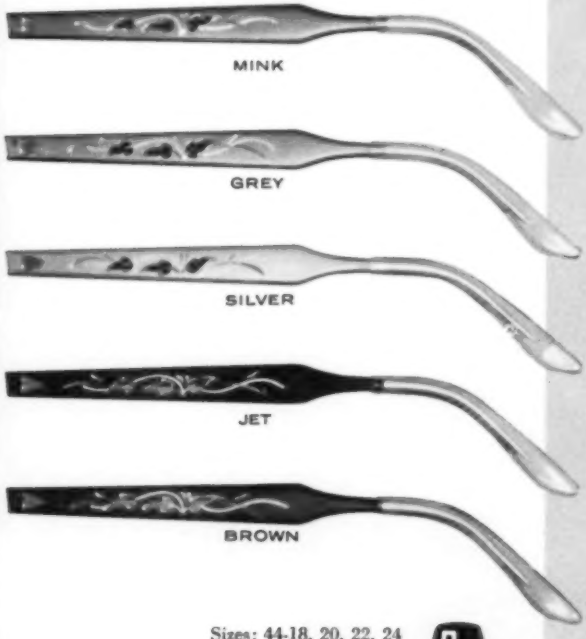

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ROY MARKS
President, Shuron Optical Company

Practitioners often ask me and other Shuron people why our company doesn't maintain its own laboratories. Often rumors crop up to the effect that Shuron is opening a captive lab system, apparently started by those who feel that we should enter this part of the optical business.

The question comes up often enough so that I think it is important that we answer it for all . . . so there will be no mistaking our basic business philosophy.

First of all, Shuron has capital available through its parent company for such a venture. We have had, and I'm sure will have again, the opportunity either to purchase existing laboratories or to start new ones. So it is apparent that our reasons for not going into this business are not lack of money or opportunity.

The basic reason that we do not go into the laboratory business is that we feel the manufacturing function and the laboratory-distribution function operate best independently of each other. Only when they *are* independent do they offer the most in *service* and *product* to you.

If, for instance, Shuron were to serve this dual function, we would have conflicting interests within the same organization. Economics would dictate that we would have to be a manufacturer first, a lab-distributor second. Our thinking would be necessarily that of a manufacturer. Any laboratory-distribution network of ours would have conflicting functions, too. The laboratories would have to strive to serve you in the best possible way with a broad range of service and products. They would also have the conflicting responsibility of distributing the products of the manufacturing arm of the organization first—other products, second. The relative merits of the parent manufacturer's products could not be questioned by the captive laboratory. They would have to sell any and all products of the company with a partisan fervor.

We would certainly have to continue to sell to independent distributors. But we would be forced into the contradictory posi-

Report:

tion of being a supplier wanting to sell him products, and at the same time a competitor. Again a conflict: on one hand trying to serve the independent by selling him products; on the other hand, aggressively competing with him and taking business *away* from him.

We feel that, if we went into the captive laboratory operation, we would have too many compromises to make, that our contribution as a manufacturer would be reduced, that we would in effect simply be trying to sell direct.

Maybe you think you would prefer us to sell direct. Let's look at the advantages you have with the independent manufacturer-independent distributor system.

1—An independent laboratory distributor can offer you a broader product line and more comprehensive service. He can and does select products from many manufacturers, bring you the best that is available and those that are most suitable for you.

2—He screens products as they are introduced, and can counsel and detail you on the strengths and possible shortcomings of each product. He is not committed to support any one manufacturer. His sole interest is in serving you and helping you serve patients better.

3—One of the independent's functions is the stocking and inventory of product. A captive lab, to properly support its manufacturing arm, tries to sell you inventory, sometimes at special deals because its primary responsibility is to sell the products of the parent factory. A good independent supplier recognizes this inventory maintenance as his responsibility and serves you better because of it.

4—An independent distributor is *local*. He knows your problems because he's close to you, and, as a local business owner, he has the flexibility to meet your special needs. A captive lab is directed partially on a national basis and partially in a large regional system. Business practices are determined by executives who don't know you or your particular needs even if they do understand them.

5—We as a manufacturer can "keep sharp" by having to compete with other manufacturers in order to sell our product to the independent laboratory.

Unless your patients are pleased, you cannot exist in practice. Your independent distributor is your "silent partner," helping you to fulfill your responsibility. Only if that partner is devoted 100% to serving *your* needs can he be most effective. At Shuron, we will stand on our product advantages rather than a "captive" or direct selling system to market our goods. We want not to compete with your silent partner, because we would be injuring him. Our concern rather is to strengthen him, and so to strengthen you and the entire industry.

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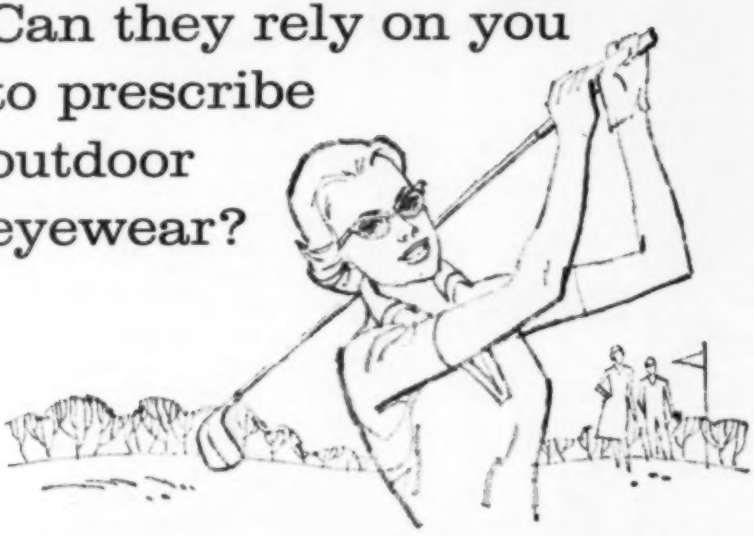

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Vol. 38 June, 1961 No. 6

ARE MEANINGFUL NIGHT VISION TESTS FOR DRIVERS FEASIBLE?*

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Division of Optometry, Indiana University
Bloomington, Indiana

I. INTRODUCTION

Statistics show that traffic accidents occurring at night are more numerous than those occurring during daylight, in spite of the fact that night traffic is far less dense. Night time fatal accident rates are greater *per unit of exposure* than day time rates by about 3 to 1 *(McFarland, et al.)*. Of all pedestrian deaths due to car accidents, 70 per cent occur at night. About 75 per cent of all night automobile accidents involve objects in the peripheral visual field *(Lebensohn)*. Although faulty vision cannot account for all night accidents, most authorities believe that a deficiency of night vision may be the cause in many cases. It has been frequently found that the driver did not see the hazard at all or did not see it in time to avoid the accident. According to *Nisemboim*, 5 per cent of traffic accidents occurring at night are due to visual deficiencies. "Eliminating this 5 per cent of traffic accidents could mean saving 2,000 lives, 70,000 injuries and over two hundred million dollars every year" (from "The Visual Factors in Automobile Driving"). Such figures will be considered in deciding whether or not a night vision test should be made compulsory for driver's license candidates. The aim of the following review is to find if such compulsory tests would be feasible.

First, the visual environment and the visual tasks involved in night driving are described in order to outline the demands made on the night drivers' visual system. An analysis of the experimental data presented shows whether or not it is possible in a test to substitute one visual function for another. A short survey is given of the factors which may affect the efficiency of the eye functions involved. Finally, the general requirements for a night vision testing procedure are discussed and some more or less appropriate instruments are described.

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This report was supported by a grant of the American Optometric Foundation for research in Night Vision for Motorists.
†M.D. Member of faculty.

II. THE VISUAL ENVIRONMENT AND THE VISUAL TASKS INVOLVED IN NIGHT DRIVING

The *field within which binocular fixation occurs* when driving is usually not larger than 8° x 5° *(Weston)*. To illustrate how much of the surround such a field embraces it may be noted that the width of an average passenger car subtends an angle of 3° 26′ at 100 feet and 0° 21′ at 500 feet from the eyes *(Danielson,* 1957). During daylight the driver occasionally throws a quick glance to the sides such that the road remains in his visual field. At night there is less tendency for a quick glance beyond the lateral boundaries of the 8° x 5° fixation field since the information gained is less than that during daylight.

The driver's level of *dark adaptation* is generally determined by a field about 60° in diameter. The "clear zone" of the visual field narrows with increasing speed, although the "speed smear" is not disturbing until it approaches the central zone *(Danielson,* 1957). The central lane and oncoming traffic are all encompassed by a 30° range. Significant, too, is the fact that beyond 60° peripherally visual acuity is so poor that we get little useful information from this area of the visual field.

During the daylight hours a driver usually fixates 200 feet ahead of the car, at night he fixates a shorter distance ahead depending mainly on the illumination produced by his headlights. If all headlights had the candle power they were designed to produce and were correctly aimed, all night drivers should have a *seeing distance* of 152 feet ahead *(Crime)*.

The night driving period extends from about half an hour after sunset to half an hour before sunrise. This is the period during which the driver uses his headlights. Determining factors for the night driver's visual effectiveness include the *low luminances* of various amounts to which his eyes are exposed during changes in fixation from the highway or street or some car in front of him, to short peripheral glances to the sides of the road, then to the instrument panel or rear view mirror and finally to the sky or horizon. His eyes will probably have an average sensitivity level determined by the luminances to which the eyes are predominantly exposed, but the sensitivity will fluctuate due to the short interruptions not only by lower luminances (which would increase the sensitivity or at least not affect the average level) but also by the more disturbing higher luminances, e.g., from the headlights of oncoming cars. The luminances observed depend, first, on the illumination and second on the luminous reflectances of the road and other observed items. The illumination is determined mainly by the driver's

own headlights. A full moon would contribute about 0.02 ft-c and in built-up areas the street lights and window lights would contribute to the general illumination. The average reflectance of a concrete road in dry weather is 23 per cent, for asphalt it is 8 per cent (*Bouma*, 1939). The white line on the highway may have a reflectance of 70 per cent. The computation of the luminance from illuminance and reflectance values is complicated by the fact that the road surface is not a perfect diffuser of light.

Data about *luminances* encountered *in night driving* are compiled in a review by *Richards* (1957) and in a book by *Jayle, et al.* (pp. 312-346). According to measurements by *Richards*, general civilian night driving is done within a range of 4 to 0.003 footlamberts (14 to 0.01 nit),* the latter value measured at the edge of the road. Occasionally, much higher and much lower luminances are viewed. Among others, snow and rain change the reflectance of the roads. The average road illumination and reflectance indicate luminances of 0.018 to 0.35 ft-L for asphalt and 0.4 to 4 ft-L for concrete roads. *Finch* (1950) determined for the upper beam headlight a highway luminance of 1 ft-L at 50 feet distance in front of the car, 0.5 ft-L at 100 feet, and 0.07 ft-L at 200 feet. The values would be lower for wet surfaces.

The areas on the sides of the road which are not illuminated would have an average luminance equal to 4.35 log $\mu\mu$L on a clear moonless night and equal to 5.75 to 6.30 log $\mu\mu$L during a full moon (cited after *Jayle, et al.*, p. 11). The sky luminance near the horizon on a clear day half an hour after sunset, equals 10^{-1} nt, on a fairly bright moonlit night it equals 10^{-2} nt, on a clear moonless night it equals 10^{-3} nt and on a moonless, overcast night sky, it equals 10^{-4} nt (approximate values after *Middleton*).

The *average level* of the *eye sensitivity* of a night driver will be *altered* from time to time by sudden increases in illumination from the headlights of oncoming cars. The effect of this illumination increase is within certain limits which are directly proportional to the total luminous flux entering the pupil and approximately inversely proportional to the second power of the angle of incidence of the light beam. The

*Candle per sq. meter or nit (nt) is the internationally accepted unit of luminance. Conversion factors:

1 footlambert (ft-L) = 3.425 nit (nt)
1 millilambert (mL) = 3.183 nt
1 Lambert (L) = 10^{12} micromicro-lambert ($\mu\mu$L)
1 mL = 10^{9} $\mu\mu$L
1 nt = 0.314 mL or 0.2919 ft-L
1 ft-L = 1.078 mL
1 mL = 0.929 ft-L
1 lux (lx) = 0.0929 footcandles
1 footcandle (ft-c) = 10.76 lx

effect depends further on the adaptation state of the eye which, as a rule, shows a high level of sensitivity at the moment of incidence: it would be higher in rainy weather because the road is darker in a wet state than when dry.

The *sealed-beam headlights* introduced in 1940 and installed in almost all standard models of cars have 75,000 beam candlepower maximum *intensity*, those which came into use in 1930 had 50,000 beam candlepower *(IES Handbook)*. The color temperature of sealed-beam headlights averages 3,025°K. For certain sizes of the blinding light source the effect is proportional to the luminance of the source. However, the data in the literature concerning the limiting angular size are equivocal. Information about the effect of opposing lights on the visibility of objects of given sizes, when the lights are incident at different angles, can be obtained from a paper by *Lauer and Silver*.

The *visual tasks* to be performed by a night driver have been summarized by *Byrnes* in an introductory statement to the Vision Research Symposium, Nov., 1957. Accordingly, the essential factors in accomplishing any driving task are as follows: Identifying the exact road surface upon which the driving is done, avoiding striking any fixed objects enroute and avoiding striking or being struck by any moving objects enroute. This requires the awareness of the status of the environment, the recognition of objects and their dynamic relationships with one another, the significance of their positions, speeds, and directions of travel. These evaluations should occur rapidly and accurately. The night driving seeing problems have been compiled by *Richards* in a monograph (1958[a]), in five literature reviews, and, also, by *Hofstetter* in a chapter about the relation of vision and visual testing to driving ability.

The properties of *objects to be detected* vary greatly from one situation to another. Their brightness, color, angular size, shape, distance, and apparent speed vary constantly while either they or the car is moving. The perceivability of objects depends on their reflectance. For example, the average man's clothing has a reflectance of from 2 to 15 per cent (see also *Finch*, 1957). Perceivability depends also on the object's contrast with the background and other physical properties of the object. The detectability of objects is better against a background which is of uniform rather than non-uniform brightness and texture. An obstacle may appear in the last seconds available in which to take action for its avoidance. According to *Simmons and Finch*, a night driver has to recognize with certainty relatively large objects, of 6 minutes angular subtense and larger, in a short period of time of from

0.2 to 0.02 seconds and a) at relatively low adaptation levels (1 to 0.005 ft-L), or b) against glare, or c) immediately after glare.

The word "visibility" in the common usage expresses the clearness with which objects stand out from their surroundings. For problems of motor driving it is convenient to use the term *visibility distance* which *Fowle and Kaercher* define as the distance at which a given object of given size and contrast can be detected in order to take proper action. Other authors distinguish a reaction-seeing distance from a perception-seeing distance. It is felt that in some papers the term "visibility distance" is used synonymously with "perception-seeing distance (visual range)." The reaction time required to push the brakes after an obstruction is visualized equals from one quarter second to one half second. This time allows the car to roll forward a distance which depends on its speed, e.g., at a speed of 70 m.p.h. the car would travel 51 feet in half a second. Another distance would be required before the car actually stops. This is also dependent on its speed.

P. W. Miles (1956) computed that at a speed of 30 m.p.h. the required total visibility distance would be 54 feet, at 70 m.p.h. minimally 160 feet. Blood alcohol content and driver fatigue would increase these distances. The Indiana driver's manual states that the avarage car must be able to stop in 56 feet distance at a speed of 30 m.p.h., in 225 feet distance at a speed of 60 m.p.h., but one should be able to stop in a shorter distance than these figures indicate. *Roper and Howard* found a 20 foot loss in visibility distance for each increment of 10 m.p.h. speed for drivers not expecting an obtacle, determined on road experiments by using a man-sized dummy in dark clothing. So far as the test went, it applied irrespective of beam candlepower and reflection values. *Haber* computed the loss percentage of visibility distance as a function of distance for various absorbing media, valid for a target having a mean linear dimension of 3 feet and a reflectance of 0.15: that is it may represent a dark-clad man. Even a clear safety plate windshield causes an appreciable reduction in visibility distance which rises more or less steeply as the initial visibility distance D_o becomes smaller. D_o assumed to exist wi.hout any interposed medium.

When the size and reflectance of a stationary object are known, it is possible from the data of the literature to figure out the visibility distance or at least the perception-seeing distance for a given night vision situation. Samples of this kind can be found in several papers, e.g., by *Lauer and Silver* and by *Finch* (1950).

Table I summarizes some important data from the literature about the night driving situation.

TABLE I
DATA ABOUT THE NIGHT DRIVING SITUATION

Luminance range	Diameter of the visual field, usually determining adaptation	Seeing distance ahead of the car	Minimal angular size of objects to be detected with certainty	Minimal time available for detection
4 to 0.003 ft-L	60 degrees	150 feet	6 minutes	0.2 to 0.02 sec.

III. NORMAL RANGE OF THE VISUAL FUNCTIONS INVOLVED IN NIGHT DRIVING

While driving at night, various visual functions come into play, namely, the ability to detect light, forms, colors, depth, distances and motion, both in the central and peripheral visual field. Each of these abilities would be altered by the following: The illumination present at night, reflectance factors, the distribution of light including glare sources, fog, rain, snow, the total time the target is visible, mechanical factors, relative speed of the car and the target, vibrations of the car, individual characteristics of the driver's eyes and his personality.

In the following section the performance of the normal eye within the range of illumination occurring at night will be given as found by laboratory experiments. The effects of alcohol and other drugs, of excessive radiations, emotional stress and fatigue are not considered. *Adaptation and sensitivity to light.*

From the luminances viewed by the night driver, one can establish approximately the stage of vision used during night driving. We distinguish *three stages of vision* according to the average luminance of the area within which the eyes are scanning:

(1) *Photopic vision* or daylight vision: the stage of pure cone activity which exists for foveal observation when the eyes are adapted to luminances above approximately 3 ft-L (10 nt). For peripheral vision the photopic limit is higher (see *e.g., Le Grand,* 1957).

(2) *Mesopic vision* or twilight vision: the intermediate stage in which the activities of cones and rods overlap, from the lower limit of photopic vision down to the adaptation luminances of approximately 3×10^{-4} ft-L (10^{-3} nt). Exact values cannot be given since the limits depend on the retinal area and region involved.

(3) *Scotopic vision* or night vision: the stage of pure rod vision, from the adaptation luminance of 10^{-3} nt down to the lowest threshold of vision at approximately 10^{-6} nt (3×10^{-9} ft-L). In scotopic vision we have a physiological central scotoma, about $2\frac{1}{2}°$ in the vertical and 3° in the horizontal meridians.

Accordingly, the night vision of drivers occurs mainly within the range of the simultaneous activity of rods and cones, the *mesopic stage*, and, also, occasionally in the low photopic and upper scotopic stages. The average sensitivity of the eye in mesopic vision corresponds approximately to that obtained in total darkness between the third and eleventh minute after extinction of a bright light (see Figure 1).

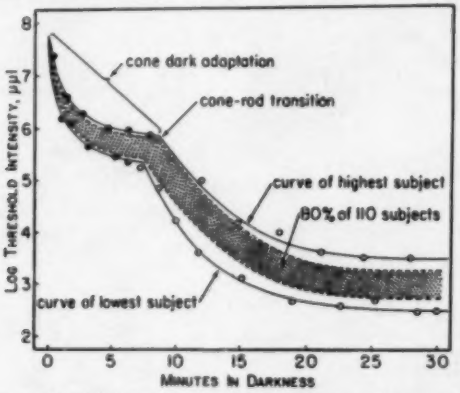

Fig. 1. The course of dark adaptation in 110 healthy normal persons. Filled-in circles indicate cone and cone-rod adaptation, unfilled circles-rod adaptation. (after *Hecht and Mandelbaum*, redrawn by G. L. Walls.)

Within the adaptation range of 4 to 0.003 ft-L, the size of the driver's *pupil* will be on the average from 4 to 6 mm. in diameter. Accordingly, the retinal illuminance will change from 144 to 0.32 trolands (2.23 to —0.33 log trolands) compensated for the Stiles-Crawford effect, or 169.8 to 0.47 trolands (2.23 to —0.33 log trolands), not compensated for the Stiles-Crawford effect as calculated after *de Groot and Gebhard*. These values are useful to know since some papers refer to retinal illuminance instead of object or background luminance.

The normal *dark adaptation* curve—the absolute thresholds plotted against the time in darkness—shows a large scattering of individual values (see Figure 1). The total spread is largest in the rod portion and equals about 1.0 log units for the terminal thresholds. Besides these variations between individuals, there are also individual daily fluctuations of approximately 0.1 to 0.3 log units of the final threshold *(Hecht and Mandelbaum)*. No differences have been discovered in dark adaptation between men and women.

That part of the dark adaptation curve which corresponds to mesopic vision shows the greatest variation range of the absolute thresh-

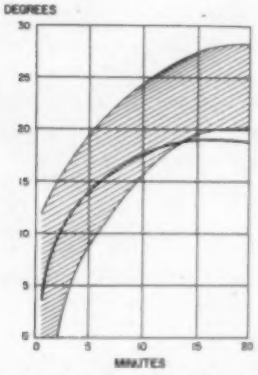

Fig. 2. Enlargement of visual fields in degrees during adaptation to a low luminance. Nasal horizontal meridian. Target 2/2000. Gray area: variability of normal isopters. Drawn-out line: pathological isopters, average of 8 persons with alimentary deficiencies. (after *Weekers and Roussel.*)

olds. For example, the onset of the kink which marks the beginning of scotopic vision may start at individually different times in spite of a constant preadaptation. *Sloan* (1947) found a maximal standard deviation of 0.38 log units at the twelfth minute of dark adaptation, the kink being reached at the eighth to tenth minute. The average standard deviation on 101 subjects was 0.28. Similarly, *Mote* found the greatest variability of the thresholds at the time of the rod-cone transition with the highest standard deviation between the 5th and 12th minutes of dark adaptation. *Van Beuningen* observed on well trained subjects that the greatest irregularities of the thresholds occurred at the first and between the tenth and fifteenth minutes of dark adaptation, whereas at the fifth and between the twentieth and fortieth minutes, they were the most stable. The instability of the thresholds during the mesopic stage may be related to the instability of the perception time, to after-images, and to intrinsic light effects.

One can check the level of *light sensitivity* of a driver by measuring his absolute thresholds on an adaptometer immediately following a driving period as was done by *Davey and Sheridan*. They found that the absolute thresholds of the examined drivers varied between the 4.47 log ft-L for the center of the city to at least 5.17 log ft-L on unlighted roads, values which correspond to an average absolute threshold obtained after 7 to 11 minutes spent in total darkness. The absolute thresholds were lower than would have been expected from an adaptation to the road, which the authors explain by the fact that this road luminance occupied a small part of the visual field only, much of the rest affected by very low luminances.

Weekers and Roussel proposed to test night vision by measuring the gradual enlargement of the *visual field* in the nasal horizontal meridian after a preadaptation of 10 minutes to 3000 lx. They used a white 2/2000 perimeter target on a Bjerrum screen illuminated by 3 lx (0.28 ft-c). In the first ten minutes there is a rapid rate of enlargement of the field, then a diminishing rate of enlargement up to the 15 minutes mark, after which there is no change in the size of the field. At this time the adaptation to the low luminance of the Bjerrum screen is complete. Some subjects with pathology show narrower fields (see Figure 2). The subject's age did not alter the result.

Glare.

We have a twofold effect following the *sudden* appearance of a *bright light* a) a simultaneous effect occurs while the light source is on, and b) an after-effect occurs when the light source is shut off. The sudden illumination can act as a source of *glare*. By glare we mean any degree of light falling upon the retina in excess of that which enables one to see clearly. According to a classification by *Bell, Troland and Verhoeff* we distinguish three types of glare. First the glare can be a *veiling* glare. In this case the light is scattered primarily by the cornea and the lens of the eye and produces a uniform veil superimposed over the retinal image of the fixated target, thus reducing contrasts. For more information see, among others, *Fry and Alpern*. Second, there is a *dazzling* glare caused by adventitious light scattered in the eye media and not contributing to the retinal image. The third type is called *scotomatous* or blinding glare, which reduces the sensitivity of the retina and causes a scotoma in the visual field. In the case of a high intensity source all three types of glare are present. It is possible to establish a BCD factor for glare which characterizes the borderline between comfort and discomfort.

When a sudden increase in illumination occurs the sensitivity of the eye shows, first, a quick drop which can be probably explained by a nervous discharge and is known as *alpha-adaptation (Schouten and Ornstein)*. This is followed by a slower beta-adaptation. In the first moment of a glare, orientation may be impossible, but after a while some details may be perceived again which depends on the intensity of the glare source and on the glare resistance of the observer. This glare resistance is individually different as was demonstrated by testing the visibility of fine wires against a direct glare source *(Simonson)*. The speed of regaining the ability to perceive in spite of the increased retinal illumination may be of vital importance to a driver.

When the light source has vanished, a sudden improvement of retinal sensitivity follows within the first 0.05 seconds which is again

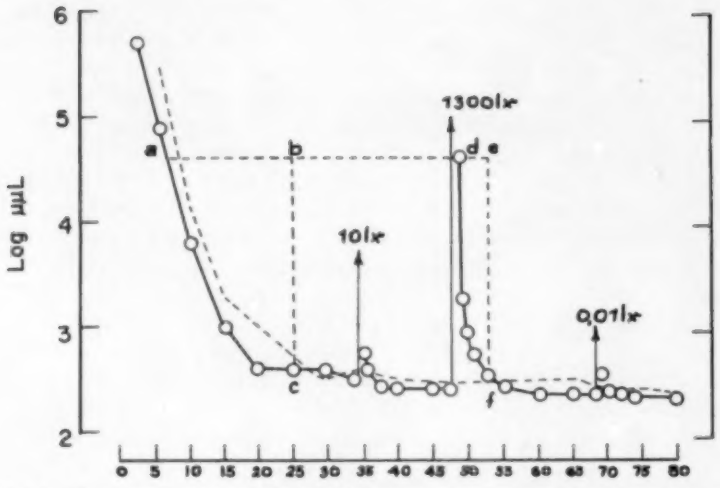

Fig. 3. Recovery of dark adaptation after interruption by illuminations of 10 lx. 1300 lx and 0.01 lx of 5 seconds duration. Ordinate: absolute thresholds. abscissa: Time in minutes. Dashed line—average of undisturbed dark adaptation. The difference between the distances a-b and d-e shows a greater speed of recovery after a short blinding stimulus than after a preadaptation of 10 minutes to 600 mL. (after *Eckel*, reprinted from *Jayle, et al.*, and redrawn.)

an *alpha-adaptation* phase. This is a fortunate mechanism since it causes a partial rapid removal of the disturbing effect of the glare source. *Baker, Doran and Miller* found recently that within the first 0.1" there is a small rise of the threshold followed by an abrupt subsequent drop. This was observed in all three levels of adaptation. The alpha adaptation is followed by the slower beta-adaptation period during which the eyes recover gradually to the previous level of sensitivity. These after-effects are most annoying after a scotomatous glare. A quick recovery from the effects of glare is essential to the driver.

The *recovery* of sensitivity following glare can be checked by measuring the *absolute thresholds*. *Grant and Mote* applied short flashes of light of 0.1 and 1 second duration, of luminances of 160 and 1600 mL, at different moments during the dark adaptation process. The flashes were approximately evenly spaced during a three-minute period. The glare source filled the 35° adaptation field of the Hecht-Shlaer adaptometer. There was an immediate recovery within 30 seconds after each flash period, except for flashes of 1600 mL of 1 second duration (and higher). *Kyrieleis* measured the recovery of a completely dark adapted eye following illumination by a light source

of a luminance of 496 ft-L (1700 nt) for 5 seconds. When blinking of the eyes was prevented, an absolute threshold corresponding to that of the ninth minute of dark adaptation was regained within 30 seconds after the glare source had vanished; the terminal threshold was obtained after 6-7 minutes. When blinking was not prevented this terminal threshold was reached after 2 minutes. With the pupil functioning the effect was not different whether blinding for 1 or 5 seconds. When the blinding was applied with the eyelids closed the rise of the threshold was insignificant. *Eckel* (1951) studied the effect of illuminations of 10; 1300 and 0.01 lx (0.93; 120 and 0.0009 ft-c) of 5 seconds duration on the terminal absolute threshold. He found that the sensitivity recovered after a few minutes and then continued along the level achieved before interruption (see Figure 3). There are individual differences. After an exposure to 100 ft-L sec. (e.g., 10 ft-L for 10 sec.; 100 ft-L for 1 sec., etc.) the *cone* sensitivity of the dark adapted eye is fully restored in a few seconds *(Johannsen, McBride and Wulfeck,* 1956), whereas that of the rods requires at least two minutes *(Hanson, Anderson and Winterberg,* 1960).

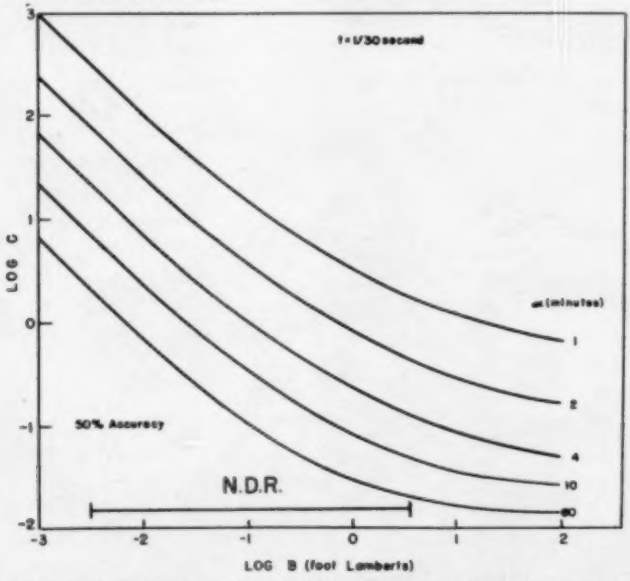

Fig. 4. Threshold contrast data for a 1/30 second duration. Each curve represents a standard disc target whose diameter is indicated in minutes of arc. The background luminance is given in log ft-L. Stimuli brighter than the background. N.D.R. = night driving range. (after *Blackwell.*)

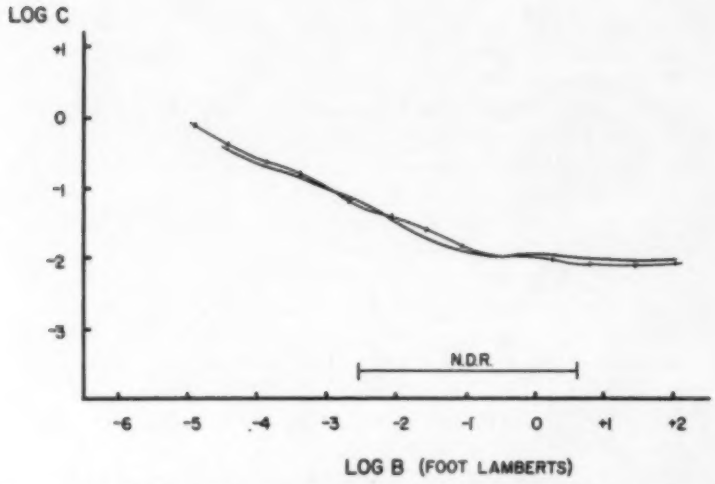

Fig. 5. Threshold contrast data for a target of 55.2 minutes diameter, brighter than the background (solid line) in comparison to those for a target of 55.5 minutes diameter, darker than the background. (Notched line.) Exposure Time 6". 50% accuracy of seeing. (after *Blackwell*.)

The glare effects show regional differences on the retina. Multiple presentations of light-dark combinations, a light phase of 1 ft-L for 10 seconds and of 10 ft-L for 1 second, indicate that duration has a greater effect than luminance on foveal sensitivity *(Hanson, Anderson and Winterberg)*.

It was stated by *Bouma* (1947-48) and propagated anew by *Davey* that *yellow light* requires a shorter recovery time than white light. Because they cause less glare, yellow headlights are in general use in France and in Czechoslovakia. However, *Richards* (1952, 1953) has been unable to find any proof of gain in night vision from wearing yellow glasses.

Time factors in vision.

The *perception time* is the interval between the beginning of a visual stimulus and the beginning of a perception. This time would be more correctly called perceptual latency time after *Strughold* (1949, 1951). Simple perception time ranges between about 35 and 150 milliseconds. During the process of dark adaptation, when using a target of constant intensity, the perceptual latency shows fluctuations in the first ten minutes. A decrease of latency time is followed by a slight increase in the first 5 minute period and a marked drop follows in the second 5 min. period. Then there is a leveling off, as established by

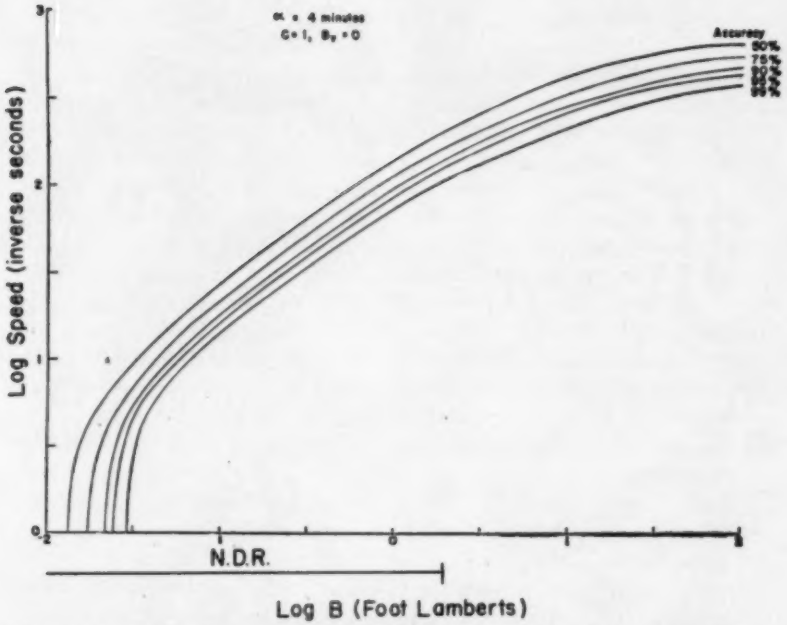

Fig. 6. Speed of performance as a function of background luminance for a black target of 4 minutes diameter on a white uniform background, for different percentages of accuracy. N.D.R. Night driving range. (after *Blackwell.*)

Kovacs, in a retinal area 4 to 8° from the fovea. A similar course was found on a 2° foveal field. For a target of constant luminance the perceptual latency time is shorter in scotopic than in photopic vision, but the dimmer the target the longer the latency time.

A term related to the perception time is the speed of performance or *speed of perception* which is the inverse of the duration of the time required to perceive a target (see Figure 6).

The *reaction time* is the time interval between the beginning of a visual stimulus and the beginning of a subject's motor response. The simple reaction time following a light signal equals in average 200 msec. The choice-reaction time, when the reaction must be performed on a specific signal or target out of several presented, is about double this time. When presenting a flash of constant luminance, the reaction time decreases during progressing dark adaptation. With dimming of the target there is lengthening of the reaction time.

When an object is perceived first indistinctly by the peripheral retina and then imaged on the fovea for distinct vision, the visual act consists of a time-consuming *chain of* successively and/or simultaneously occurring *processes*: The saccadic conjugated fixational movements of the eyes, convergence, accommodation, and pupillary reaction. Saccadic intrafixational movements (from one fixation point to another) and convergence may be termed ophthalmokinetic adjustment of the eye for distinct vision, accommodation and pupillary constriction dioptric adjustment *(Strughold)*. The former is a rapid process while the dioptric adjustment is relatively slow. The *chains of latencies* before distinct foveal perception is attained consume a time range from 200 milliseconds as a minimum to over 1000 milliseconds. According to observations by *Schmidt and Strughold*, a glance to the side and back might consume at least 0.6", a glance from far to the instrument panel and back will in any case require more than 1.2". It is very instructive to figure out these time periods in terms of distances when the speed of the car is known.

Contrast sensitivity.

As already mentioned, the ability to see fine details is not the most important visual function of the night driver, but the recognition of gross *forms*, a somewhat coarser function than visual acuity. The obstacles usually appear either as a black "negative" silhouette, when illuminated from behind by an approaching car or against the illuminated highway, or as a "positive" silhouette when illuminated by the driver's own headlight against the dark background. The recognition of the presence of a form is mainly a function of *brightness differentiation*, in other words, *contrast sensitivity*. The contrast sensitivity is computed from the reciprocal of the threshold of brightness contrast. The formula for the threshold contrast is $C = B_u - B/B$ where B_u is the luminance of the object that can just be perceived as being brighter than the background luminance B, the observer being adapted to B. When the object is brighter than the background, the contrast range is from 0 to ∞, when it is darker than the background, it is 0 to —1. In order to avoid negative contrasts one can compute the contrast of an object which is darker than the background from the relationship $C = \frac{B - B_u}{B}$. Then black letters on a white background would produce a contrast of +1 or 100 per cent. The formula for contrast can be written also as $C = \frac{\pm \Delta B}{B}$.

In Figure 4 contrast data by *Blackwell* (1955, 1959) are presented which were collected under the following experimental conditions: Luminous disc brighter than the background on a background of uniform luminance, binocular observation with natural pupils, and the subjects knowing the location of the target. For application to the problem of night driving *Blackwell* chose data obtained with a 1/30 second exposure time as the most appropriate. On a longer duration the contrast thresholds would be lower. Figure 4 shows that a smaller object requires more contrast. The night driving range is designated by the line N.D.R. and encompasses the luminances between 4 and 0.003 ft-L (0.60 to —2.53 log ft-L).

In photopic vision an independence of the contrast threshold from the size of the object occurs from a diameter of 1° and up, whereas in the dark adapted eye this limit is much higher. The percentage of correct answers is a measure of the accuracy of the brightness discrimination, which in Figure 4 is 50 per cent. However in daily life we would be more interested in an accuracy of 99 per cent. *Blackwell* (1955) suggests a factor of 1.86 in order to convert contrast data obtained on a 1/30 second presentation and 50 per cent accuracy into such with 99 per cent accuracy. It would be reasonable to suppose that the contrast threshold for common sense seeing would be still higher than the laboratory threshold, even for 99 per cent accuracy.

Contrast thresholds for objects darker than the background, when expressed as positive values, show about the same trend as those of objects brighter than the background (see Figure 5).

From an experimental series with constant but with different exposure times of the target, *Blackwell* (1957) evaluated the effects of target size, contrast and background luminance upon the speed of performance, the latter being expressed by the inverse of the target exposure time. The speed decreases with decreasing luminance as seen in Figure 6 on a target of 4 minutes diameter. In case of smaller targets and targets with little contrast longer times are required.

The quoted contrast data are valid for stationary objects. Usually an object that moves across a field is more noticeable than when it does not move, both in central and peripheral vision. However, the *contrast thresholds of moving point light sources* are higher than those of the same objects when stationary. To perceive a point light source moving with an angular velocity of 1.3° per sec., e.g., an artificial satellite, on a background of night sky luminance requires a luminance which is one star magnitude higher than that of the same object when stationary. On higher background luminances, the required increase of the threshold

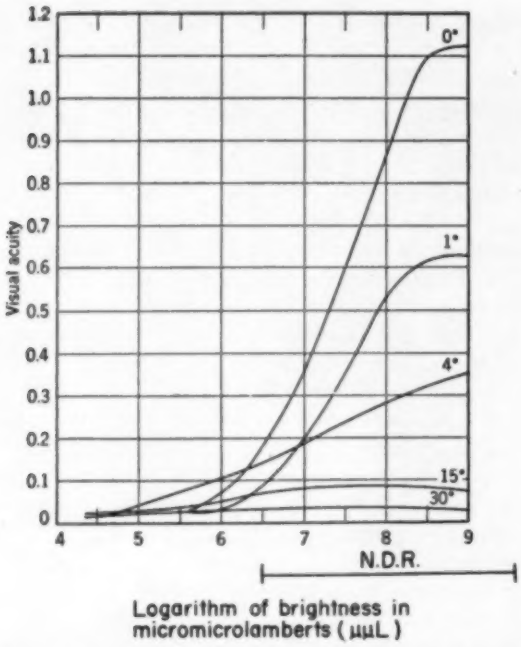

Fig. 7. Visual acuity plotted as a function of background luminance, for retinal images at 0°, 1°, 4°, 15°, and 30° distance from the fovea N.D.R. Night Driving range. (after *Mandelbaum and Rowland*, reprinted from *Chapanis*, "How We See?")

is still greater *(Gulledge, et al.)*. *Pollock* found for the dark adapted eye a linear increase of the threshold luminance with increasing speed using a 1° circular white spot moving with an angular speed of 50 to 2000° per sec. When the total exposure was at least one second, *van den Brink and Bouman* did not find a difference in the threshold value for a point light source moving with a speed of 80 minutes per second or slower, in comparison to the stationary light. On shorter exposure or with high background luminances, the stationary target was visible on a lower intensity than the moving target.

Visual acuity.

Very useful for an orientation about *visual acuity in night vision* are the experiments of *Mandelbaum and Rowland*. (Figure 7.) One can deduce from the data that for a dark object and background luminances of 4 to 0.003 ft-L visual acuity would range foveally from above 1.0 to 0.17 and at 4° temporalwards it would range from about 0.37

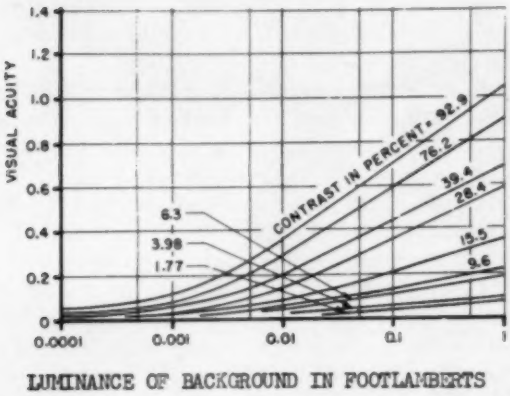

Fig. 8. Visual acuity as a function of background luminance and luminance contrast between object and background. (after *Conner and Canoung*, reprinted from "Vision in Military Aviation.")

to 0.14. At the farther periphery the values for visual acuity are very low. It is of interest to note that in scotopic vision the best visual acuity is not found at the retinal region of maximal light sensitivity, that is 15 to 20° peripherally, but around 4-5° from the fovea (on the temporal side). According to *Nowak* the best visual acuity in scotopic vision is found near the boundaries of the central scotoma, at 1° above the fovea and at 1.5° from the center in other directions. It has been repeatedly observed that visual acuity is better when there is some dim luminance present in the visual field (e.g., the night sky) than in total darkness.

Figure 8 shows the dependence of *visual acuity* on the *background luminance* and on the *contrast* for objects darker than the background (Landolt rings). The 7 subjects observed binocularly with natural pupils, on higher luminances foveally, on lower luminances parafoveally, then fixating 5° above the center. They adapted extensively to each particular luminance. The curves show a deterioration of visual acuity not only with decreasing contrast but also with decreasing luminance *(Conner and Ganoung)*.

The quoted experiments on visual acuity concern resolution of stationary objects, the so-called *static visual acuity*. For drivers, the *dynamic visual acuity* is of prevalent importance when the object is moving or when the driver is moving, e.g., while reading traffic signs. Dynamic visual acuity has been studied by *Ludvigh* and his co-workers, mainly in photopic vision, for constant distance between observer and

target. Independently of static acuity dynamic visual acuity begins to deteriorate with movements of the target (or with eye movements) of 20° per second, though not appreciably until 30° per second *(Ludvigh and Miller; Goodson and Miller)*. Dynamic visual acuity shows a predictable impairment with increasing angular velocity which can be explained by the decreasing contrast from the blurred target, since the pursuit movements of the eye are less and less capable of steadying the image of the target on the retina *(Ludvigh,* 1949). Whereas static visual acuity does not increase above a certain luminance level, dynamic visual acuity still improves with increasing illumination for higher velocities as checked by using Landolt rings on a white background. *Miller* tested dynamic visual acuity on lower luminances down to about 0.034 ft-L by increasing velocity and found a more rapid deterioration with decreasing luminance. *Low* found in the retinal periphery the dynamic visual acuity (which he misleadingly called motion acuity) with an object moving about 15° per second, measurably lower than the static visual acuity. Between 30° and 60° peripherally it was so poor as to become negligible.

Color vision.

The usefulness of *colors* for differentiation of objects in mesopic vision is limited, since at the corresponding luminance ranges perception of colors gradually disappears. Below about 1 ft-L our color vision tends to become similar to that of a blue-yellow defective, observed by *Brown* (1951) on a 2 degree field in a dark surround. Also, short exposure, small size or excentric stimulation will deteriorate normal color perception still more in dim illumination. In mesopic vision colors would support the distinction of details mainly according to their luminosity which would vary at different levels of illumination in accordance with the Purkinje shift. From a review by *Farnsworth* it follows that small colored areas would be recognized correctly in foveal vision when they provide sufficient luminous energy, the limiting value presented by a certain product of area x intensity x time.

Discrimination of depth and distances.

Stereoscopic vision is effective as a factor of depth discrimination up to a distance of 200 meters (656 feet). Its threshold can be expressed by the angular disparity of the images in the two eyes.

Mueller and Lloyd measured the threshold of stereopsis for luminance levels of —4.04 to 2.27 log mL, starting with the lowest luminance, after 25 minutes of dark adaptation, and allowing two minutes adaptation to each luminance level. Depth discrimination became impaired with decreasing luminances. When the stereopsis angle was

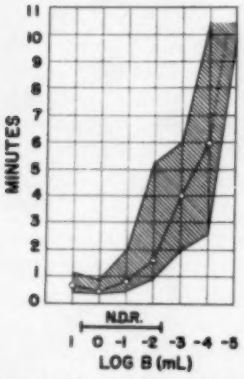

Fig. 9. Range of individual variability and average of depth perception of 62 emmetropes with normal dark background adaptation, at different levels of luminance. Abscissa: Luminance in log mL. Ordinate: Angle of disparity in minutes of arc. N.D.R. = night driving range. (after *Sachsenweger*, reprinted from *Jayle, et al.*, and redrawn.)

plotted against luminance a curve resulted indicating the usual rod-cone discontinuity of the visual function with a kink at about —2.2 log mL. Discrimination of depth seems to be possible in scotopic vision. That the sensitivity of distance discrimination decreases with decreasing illumination was shown also by *Hirsch and Weymouth* for luminances from 25 mL to 0.0005 mL. With objects of luminances above foveal threshold, stereoacuity, which is the reciprocal of the stereopsis angle, decreases in the dark adapted eye *(Streckfuss)*. *Sachsenweger* established a marked diminution of stereoacuity with diminishing background luminance and a considerable individual variability of values, especially in mesopic vision (see Figure 9). He observed also that stereoacuity is affected by night myopia in a manner similar to visual acuity and that heterophorias affect stereoacuity, especially in dim illumination.

Where stereopsis practically ceases to be a cue for discrimination of depth (beyond about 200 m) the empirical or *secondary factors*, especially the factor of *linear perspective* and the *motion parallax*, still enable a judgment of relative depths and distances. When we do not perceive the surroundings of a target at night, the problem is that of a localization in a structureless field which, as we know from psychological experiments, allows the judgment of the distance of a target from its angular extent only. When the real size of the object is known, the judgment of the distance may be correct. The motion parallax can be observed when the object is moving or when the observer is moving, e.g., the driver of a car. Objects at different distances show a different

apparent movement with respect to speed and magnitude of displacement. See the book of *Gibson* for more information. Another empirical factor, the *aerial perspective*, can become effective at distances important for drivers. In foggy weather contours become indistinct and the contrasts are reduced, effects which cause an overestimation of distances. It has been observed that two objects appear farther apart from each other in mesopic vision than in bright daylight, which is probably due to the indistinctness of contours in the dimmer illumination *(Sachsenweger)*. In general, when decreasing illumination white surfaces on a dark background appear smaller and apparently moved to a greater distance, whereas dark areas on a lighter background appear larger and nearer. Reducing the retinal illumination in one eye only would then cause an apparent rotation of a frontoparallel surface in binocular vision. Unequal vision of this type causing distortion of visual space has been called *anisopia* by *Cibis and Haber*. They found the anisopic stereoeffect increased linearly upon darkening one eye by a neutral density filter up to 0.05 transmittance. Anisopic effects cannot be predicted on a geometrical basis alone.

Discrimination of motion.

Errors in judgment of distance and speed rank among the prime causes for night accidents. In measuring the discrimination of *motion* we distinguish a *speed* or a rate *threshold* (minimal distance per unit time on a just perceptible motion) and a *displacement threshold* (minimal displacement necessary to perceive a motion). A *differential speed threshold* measures the just noticeable acceleration or deceleration. A motion can be perceived better in a structured field with fixed reference points than in an unstructured field. The displacement threshold is higher in dim illumination and is more noticeably affected by illumination in peripheral vision than in foveal vision *(Basler)*. The lower the luminance (applying luminances —1.0 log mL, —3.4 log mL and —4.0 log mL) and the more peripheral the retinal region, the larger must be the object in order to perceive motion. *(Warden and Brown)*. It seemed that under the experimental conditions chosen that the target had to exceed form threshold before motion was perceived. By using a pattern of black and white stripes *Hodel-Boos* found the threshold of motion centrally and peripherally about 3 times higher after 15 minutes dark adaptation than in photopic vision. In scotopic vision the scatter of values is greater, as long as the eyes are not sufficiently adapted. That the *differential* angular *velocity* increases with decreasing illumination was shown by *Graham* and co-workers. Motion is more easily perceived when the moving objects are seen from the side, moving laterally

than when viewed approaching the observer, however generally usable data are not given *(Kephart and Besnard)*.

The position and motion of a single light in a structureless surround becomes indeterminate. A stationary light makes random excursions in any direction, apparent motions known as *autokinetic movements*. The autokinesis is greatly reduced when two lights are present and largely abolished by more than two lights *(Graybiel and Clark)*. A difference in retinal illuminance of the two eyes can cause an erroneous perception of motion. A pendular motion in one plane may appear as a circular motion, an effect known as the Pulfrich stereophenomenon.

Effect of vibration and noise.

By testing the visual acuity of a person sitting on a vibrating chair, *Coermann* found two critical frequency ranges producing a minimum of visual acuity, namely 25 to 40 cps and 60 to 90 cps. Using contrast thresholds as criteria, *Krauskopf* established that in the absence of normal image motion low frequency vibrations of 1, 2, or 5 cps of the retinal image were beneficial to maintained vision, while higher frequencies of 10, 20 and 50 were detrimental to continuous vision. In both instances the amplitude for a demonstrable effect had to be at least 1 minute of arc peak-to-peak. *Ercoles, et al.*, found that vibrations over 10 cps decreased visual acuity through a range of amplitudes, the latter expressed as ¼ to 2 times the grating spacing employed. Whether or not the effect of vibrations have any significance for the night driver's vision requires further research work.

Effects of noise on night vision have been reported by Russian authors, however the reports could not be verified *(Rose and Schmidt, Chapanis, Rouse and Schachter)*.

Night myopia. Eye muscle balance in dim illumination.

A much discussed problem in connection with night driving is that of night myopia. The latter amounts from —0.50 to at least —1.50 D. According to *Richards* (1958) not all persons show night myopia at driving levels, therefore a universal prescription to correct it would not be justified. Night myopia may be related to empty field myopia which occurs on lack of accommodation and fusion reflexes and impairs judgment of size, distance and speed *(McDonald)*. Night myopia should then affect vision of the night driver only temporarily. It is demonstrable in mesopic vision and gradually increases as luminance decreases *(Knoll)*. In older persons it is not of as great an amount.

Helmholtz noticed that depth perception due to retinal disparity

is markedly supported by small eye movements causing retinal images to constantly stimulate different receptors. Modern authors are of the belief that the retinal disparity evokes such oscillatory eye movements or at least leads to innervations for eye movements which serve to increase depth perception. On the basis of this theory it is understandable that diminution of luminance decreases stereoscopic acuity, since eye movements and fusional movements become slower in dim illumination. *(Piper)*. A slowing down of eye movements should also affect dynamic visual acuity since pursuit eye movements play an important part in this function. Because clues to stimulate the two eyes into fused binocular vision become fewer with decreasing environmental luminance, it is understandable that persons with marked heterophoria and muscular deficiencies can suffer from diplopia in dim illumination *(J. Hofstetter)*. *Ivanoff* established that at luminances below about 10^{-3} nt the eyes start to converge independent of any testing distance, since at low levels of luminance the fusional reflexes are obviously diminished or suppressed. The night convergence is not related to heterophorias since 4 of his 9 subjects were exophoric but still showed the convergence in darkness. Ivanoff regards the night convergence as the primary cause for night myopia, the latter occurring reflexly. Contrary to this, *Otero, et al.*, assume that the night convergence is a consequence of night myopia and that on avoidance of convergence the night myopia remains. Several authors noticed a loss of accommodation in scotopic vision which was related to the loss of accommodative reflexes due to the central scotoma. *Le Grand* (1942) found that his accommodative power was at half its value at 0.1 nt (3×10^{-2} mL) and disappeared entirely at 10^{-3} nt (3×10^{-4} mL). He noticed also an increased convergence. *Palacios* described a migration of the far point toward the near point which caused a narrowing of the accommodative amplitude in darkness. Recently *Blackwell* (1957) reported about data, collected by *Alpern*, according to which in mesopic vision the near point moves out and the far point moves in, so that the amplitude of accommodation is reduced as light level decreases (Figure 10). *Blackwell* reports further on some recent data about the relation between accommodative vergence and luminance. These show that the accommodative vergence reflex does not operate at low levels as completely as at high levels of illumination (not tested below log 0 trolands retinal illuminance). The remaining part for binocular alignment must then be fulfilled by fusional convergence.

Psychological factors.

The perceptual ability in night vision includes variables which are

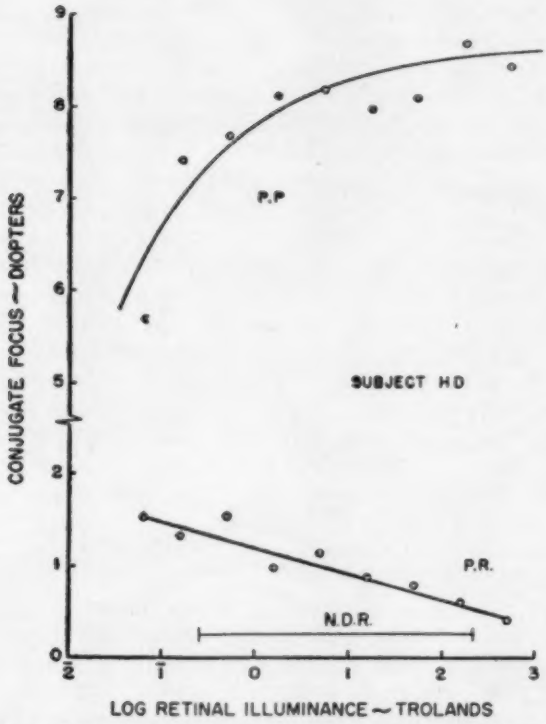

Fig. 10. Near point (P.P.) and far point (P.R.) for various luminances. N.D.R. night driving range. (after *Alpern*, redrawn from *Blackwell.*)

difficult to incorporate in a night vision tester, namely, *psychological factors.* The discrimination of forms depends not only on the mosaic of the retinal receptors and on the distribution of brightness on the retina, but also on some contributions made by the observer himself, depending on his intelligence, his education, experience with the particular situation and material. Familiar forms are recognized faster than unknown forms, an unexpected object may be recognized slower than an expected one. Experiments concerning vision in illumination by motor car headlamps revealed that the average driver perceives the unexpected obstacle half as far away as the expected one *(Roper and Howard)*. Gestalt factors play a role in separating a form from its background. The perception will depend on the alertness or the state of fatigue of the driver (see also *Craik and Vernon*). In case of danger

the driver will be under a certain stress and we do not know how his visual functions are affected by this emotional component. We have no such well defined standards for the psychological factors involved as we do for visual acuity in physiological experiments.

It must be borne in mind that in many experiments the data are obtained after the eyes have been adapted completely to a given background, whereas in driving the illumination may change so rapidly that the sensitivity level in a given moment lags behind the adaptation luminance. This will be the case when proceeding from a higher to a lower level of illumination, for example, after having passed a town rather than when entering the town. A glare source may cause a sudden drop in sensitivity (α — adaptation). And it should be emphasized that the application of the laboratory findings to the situation in driving has some difficulties for when a driver approaches a target its illumination, angular size, angular speed and its distance vary continuously. The effect of the windshield may not be neglectable. Moreover, when applying experimental data to the situation in driving one should be aware that in the laboratory the experimenter concentrates upon only vision during the experiment, while a driver is not concentrating his whole attention and energy on the task of seeing.

IV. CORRELATIONS OF VISUAL FUNCTIONS INVOLVED IN NIGHT DRIVING

It follows from the preceeding discussion that there is a great variety of visual functions involved in night driving. Since it is very difficult to design a test which includes all of them, it appears necessary to discuss their correlations in order to establish whether or not the testing of one function can be substituted for the testing of another.

Correlation between cone and rod vision.

Of prime interest is the correlation between *cone* and *rod vision*. There are some pertinent data concerning *absolute thresholds*. Among the 110 persons investigated by *Hecht and Mandelbaum* (Figure 11) the correlation between the final cone and rod thresholds was low. *Sheard* found a correlation coefficient for the final rod and cone threshold of +0.63. From these data one can draw the conclusion that it would not be sufficient to test rod dark adaptation or cone dark adaptation only.

Correlation studies between rod and cone vision were also made concerning *visual acuity*. *Beyne and Worms* found a correlation coefficient for photopic and scotopic central acuity of +0.09. *Uhlaner, et al.*, determined a moderate relationship between scotopic and photopic acuity scores and a higher relationship between scotopic and mesopic

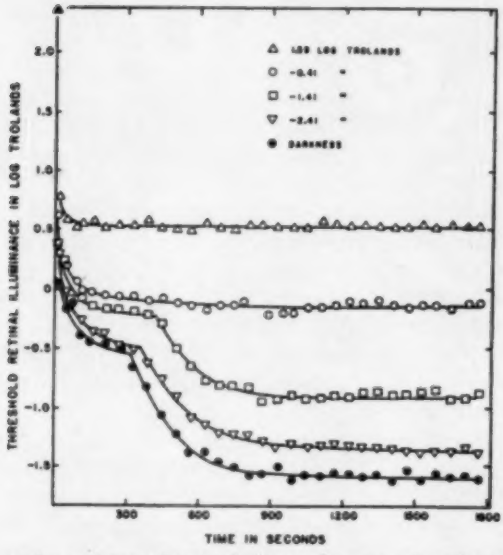

Fig. 11. Adaptation to intermediate levels (upper four curves) and to complete darkness, lowest curve, 8° from the fovea, temporal retina. The black triangle at time 0 is the difference threshold to the preadapting retinal illuminance. (after *Hattwick.*)

acuity scores. Other authors found the visual acuity of rods and cones to be entirely independent. *Rose* states that visual acuity data in mesopic vision do not allow a reliable estimation about this function in scotopic vision and *vice versa.* It is also not sufficient to test the recovery of visual acuity immediately after extinction of a glare source, since one can find persons with excellent immediate recovery data but low terminal sensitivity and *vice versa.*

On the other hand when considering the density of receptor population and the ratio between the number of rods and cones, *Scott and Solandt* found a constant ratio of photopic to scotopic visual acuity in a retinal region between 25 and 50° from the fixation point. This may be a scientific detail with no significance for practical testing.

Correlation between dark adaptation and contrast sensitivity.

Of prevalent importance for the designing of a night vision tester are the correlations between *dark adaptation* and *contrast sensitivity* and also *dark adaptation* and *visual acuity.* Wartime reports showed that measures of dark adaptation did not correlate with scores on tests involving form perception at rod levels of luminance and that percep-

tion of a silhouette is only partly determined by the absolute threshold in cone vision and still less by that in rod vision *(Chapanis, Garner and Morgan)*. *Eckel* (1951a) is of the opinion that a fast dark adaptation during the fifth to fifteenth seconds and a good terminal form perception at night are associated with good practical night vision but not with either the recovery in the first minutes after glare or the terminal absolute threshold. *Jayle and Ourgaud* (1950) found that good adaptometer values may go along with bad orientation at night, due to some pathology. *Craik and Vernon* stated that the perception of a simple figure, e.g., the reading of the position of a dial indicator was closely related to the absolute thresholds, but perception of more complicated material such as silhouette pictures was only partially determined by the absolute thresholds and was less in rod than in cone vision. They assume that the interpretation of data was affected by psychological qualities.

Hattwick compared the recovery to complete darkness with the recovery to intermediate illuminations. He started with a readaptation to bright light and then, similar to the dark adaptation procedure, established at certain time intervals the just noticeable target luminance on a background of constant low luminance B, until the values leveled off. The terminal values when expressed as contrast thresholds would be comparable to the data of *Blackwell*. Such curves are shown in Figure 11 for a retinal area 8° from the fovea and using a 1° stimulus. The thresholds are given in trolands, but can be easily converted into log equivalent luminances by using the formula log B(mL) = log E (trolands) — 1.03, since the pupil area was 3.31 mm.^{2} The upper two curves are similar to those obtained on foveal observation and also similar to the foveal curve of the absolute thresholds. Obviously the retinal illuminance of log —0.41 trolands stimulates cones already. These two curves are of interest for the problem of night driving because the background luminances correspond to rod luminances at night. It is noticeable (but not in Figure 11) that the final sensitivity level for the cone vision is reached sooner when adapting to low luminances than when adapting to complete darkness. This is not the case for the rods as seen in the two lower curves in Figure 11, which resemble the usual dark adaptation curves.

Pollak and Wilson found that persons with identical absolute thresholds showed marked differences in contrast sensitivity, the latter obviously related to their ability to see in the dark. That these are different functions can be deduced also from the fact that some persons improved their contrast sensitivity by taking Vitamin A together with

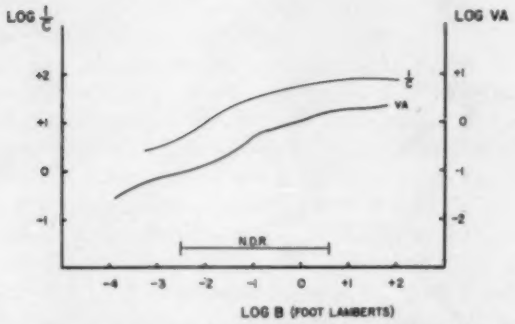

Fig. 12. Upper curve: contrast sensitivity (1/C) for a disc of 18.9 minutes diameter (redrawn after *Blackwell*). Lower curve: visual acuity (V.A.) (redrawn after *Shlaer*). Abscissa: luminance B in log foot-lamberts. N.D.R.—night driving range.

brewer's yeast products, a diet which had little effect on their absolute thresholds. According to *Durup and Rousselot* there is an insignificant slight correlation between differential and absolute thresholds.

Correlation between dark adaptation and visual acuity.

Concerning comparisons of *visual acuity* and *absolute thresholds* we can omit those experiments made in scotopic vision only.

When testing visual acuity during the dark adaptation process by increasing the luminance until a form of given size is resolved, the obtained threshold luminance curve will be similar in shape to the dark adaptation curve but higher than the latter, since more luminance is needed to perceive a form than to perceive light. *Pinson and Chapanis* compared the absolute thresholds and those for form perception as for Landolt rings of different sizes. The size varied as necessitated by the illumination level, using background luminances between 3.6 μL and 0.008 μL as encountered outdoors at night. There was no correlation between these two functions over the luminance range studied. In correlations of form perception there appeared to be a dividing line at a luminance level of approximately 0.5 μL. The correlations above and below this level were very good but at this level they were poorer. Thus, the range of mesopic vision shows a correlation other than the range of pure rod vision. *W. R. Miles* determined a mean difference of 1.010 log $\mu\mu$L of the luminances required for form and light thresholds in rod vision, which was 0.167 log units more than in cone vision, both measured on a retinal region 7° nasally. In general, the authors emphasize that both functions should be measured at the same retinal region and that low correlations may be due to some extent to the fact that this point

was not always considered. *Brown, Graham, et al.*, explored the foveal luminance threshold for the resolution of a grating during dark adaptation. They obtained threshold curves that had the conventional appearance of cone dark adaptation curves with a steady level having been reached after about 7 to 10 minutes. Coarser gratings, obviously affecting also rod vision, yielded curves similar to dark adaptation curves showing an initial activity by the cones and a delayed activity by the rods. *Pirenne, Marriott and O'Doherty* found that the correlation between the absolute thresholds and the resolution of a black Landolt ring during dark adaptation was reduced under certain conditions. They conclude that it would not be sufficient to test only with a patch of light to make the test have a meaning for night driving ability.

Correlation between visual acuity and contrast sensitivity.

Figure 12 shows visual acuity data by *Shlaer* in comparison to *contrast thresholds* by *Blackwell* (1946). Shlaer established *visual acuity* by using black Landolt rings of different sizes. After a preadaptation to darkness the subject completely adapted to each luminance level, starting from the lowest level. He observed with the right eye through a 2 mm. artificial pupil but without a fixation point so that he was free to use parafoveal vision at low luminances. Blackwell's data are reciprocals of the contrast thresholds (in order to express contrast sensitivity) for a 18.9′ disc darker than the background, requiring a visual acuity of about 0.05. The experimental conditions were similar to those used by Shlaer, except that Blackwell had 25 subjects observing binocularly without artificial pupils. When the results of both authors are plotted against luminance on the abscissa the curves are to have shown a very similar shape. *Hendley* determined visual acuity and contrast thresholds in similar experiments. When he plotted visual acuity as a function of contrast he got no simple relationship. Visual acuity depends on the brightness contrast between object and background, and, conversely, brightness discrimination depends on size, both functions varying with the brightness of the background. Visual acuity and contrasts were directly related over a very short range of luminances only. *Schober* (1954) is also of the belief that visual acuity and brightness differentiation during dark adaptation do not necessarily correlate. Hence, in spite of some parallelism it is not safe to use contrast thresholds as a substitute for visual acuity thresholds in measurements at dim illumination.

Correlation between static visual acuity and dynamic visual acuity.

Of uppermost interest for the driver's night vision is the correlation between *static* and *dynamic visual acuity*. Up to now studies in

this respect were made in photopic vision only. *Ludvigh and Miller* found a very slight correlation, the dynamic visual acuity being tested by identifying Landolt rings at velocities 10° to 170° ps. *Hulbert and Burg* stated that the correlation between sign reading while in a simulated driving situation and static visual acuity is not statistically significant. This question has been further investigated by *Hulbert, et al.*, under experimental conditions which are nearer to the actual driving situation than those of *Ludvigh and Miller*. It follows from these experiments that the critical speed that differentiates static acuity from dynamic acuity is probably between 60° ps and 120° ps since at angular speeds of 20° ps and 60° ps there were product-moment correlation coefficients of +0.41 and +0.43, respectively, whereas at 120° ps and higher, correlations were insignificant.

Correlation between visual acuity and motion acuity.

Attempts have been made to correlate *visual acuity* thresholds with *motion acuity* or *displacement* thresholds in dim illumination. However, the parameters for these visual functions are too different to allow a useful comparison.

Correlation between visual acuity and depth discrimination.

Finally, it may be mentioned that the correlation between *vernier acuity* and *depth discrimination* has been studied. The depth function was more affected by brightness changes than the vernier function, the thresholds being expressed in seconds of arc *(Berry, Riggs and Duncan)*.

From the correlation studies we find the following:

(1) that a conventional dark adaptation curve would not give the desired information about the night vision abilities of a driver.

(2) that it is not correct to predict mesopic vision data from the data found in scotopic vision. Also, the ability to recover after glare is not related to night vision abilities.

(3) that although there are similarities in the results of contrast threshold measurements and visual acuity threshold measurements at different luminance levels, or between luminance thresholds required to discriminate a form and absolute thresholds, it is safer to test the specific function about which we desire to get information. It should be tested under conditions of road levels of illumination.

V. NIGHT VISION DEFICIENCIES

Before an introduction of night vision testing for drivers it would be of importance to tell the number of persons suffering from a night vision deficiency. The number of congenitally night blind persons is very low. Exact figures are not available. However, persons with acquired disturbances of night vision due to pathology are less infre-

quent. Statistical studies based on careful tests, adequate controls and correct standards indicate that not more than 2 per cent of the population of the U.S.A. show abnormally high or pathological levels of absolute thresholds *(Sheard,* 1944). A survey in Australia *(Motorists' Vision)* uncovered inadequate dark adaptation in 9 per cent of drivers. A screening of 655 persons with the Goldmann-Weekers Adaptometer (see later) revealed that about 5-10 per cent of night drivers in Germany have disturbed night vision *(Peukert)*. A preliminary report of the National Home Demonstration Council and the Woman's Auxiliary of the American Optometric Association's Vision Committee concerning findings on the actual abilities of auto drivers stated that 5 per cent of the persons tested had inadequate glare resistance. (Reported by *Bryan.*)

Congenital night vision deficiencies.

In *congenital night blindness* the rods are at least functionally deficient. In most cases there is no kink in the dark adaptation curve and the rod portion continues at the level of the final cone portion. As a peculiarity it may be reported that *Carroll and Haig* observed a family with congenital night blindness, two members of which drove at night, but were unable to walk unaided in darkness. One had a dark adaptation curve coinciding with the cone portion of normals: the other had higher absolute thresholds than in the normal cone portion. When driving they obviously utilized that partial vision in mesopic range performed by the cones.

A congenital type which shows disturbances in the photopic and mesopic shapes due to lack of cone vision is found in *total color blindness* or achromatopsia. There are again two types. The typical achromatopsia or cone-blind form has a pure rod-type dark adaptation curve, the kink being absent. After a high preadaptation luminance the first part of the curve is abnormally high, explainable by an absence of cone function, since during this stage the normal cones would respond to a much lower luminance *(Sloan and Newhall)*. The visual acuity of typical achromats in photopic vision equals that of normals on low luminances. The atypical or cone-color blind form does not show abnormalities of night vision.

Red-green deficient persons have normal dark adaptation. One should not test visual functions of protanopes and protanomals with red light in the first minutes of dark adaptation because of the decreased luminous efficiency of long wavelength in their cone vision.

Acquired night vision deficiencies.

Acquired night vision deficiencies can be caused by nutritional

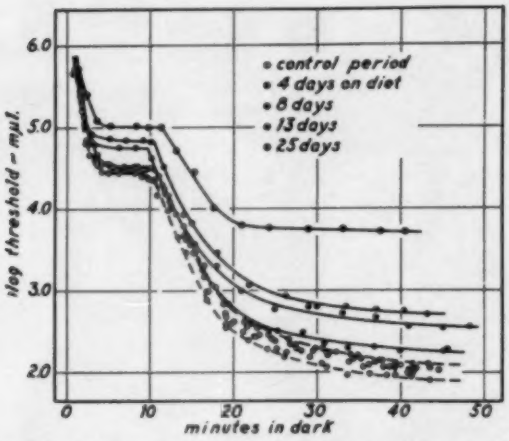

Fig. 13. Dark Adaptation curves of a control period of optimal vitamin A nutrition (open circles) and after various intervals on a diet deficient in Vitamin A. (after *Wald, Jeghers and Arminio.*)

deficiencies, general illness, psychic disturbances, pathology of the eyes and physiologically by age.

It is known that vitamin A deficiency impairs night vision. *Jeghers* reports about 5 car accidents directly attributable to vitamin A deficiencies. It increases both foveal and extrafoveal thresholds in all levels of adaptation. This is most obvious in scotopic vision (see Figure 13). In photopic vision the impairment is usually not noticeable because then threshold vision is rarely utilized. Some persons with a vitamin A deficiency show constricted fields in dim illumination (*Sloan*, 1947). It also affects brightness differentiation *(Pollak and Wilson)*. Persons with vitamin A deficiencies usually suffer from photophobia and are easily dazzled by oncoming car headlight beams. They also show a retarded recovery after being blinded by glare *(Jeghers)*.

An effect similar to vitamin A therapy in preventing night blindness can be obtained by *beta carotene*, a precursor of vitamin A. Of other vitamins, B_2 seems to have a normalizing effect on night vision. *Pock-Steen* believes that it has a specific effect on mesopic vision. But in most cases the mechanism seems to be a facilitation of the vitamin A utilization in the liver, caused by the B_2 therapy.

Seasonal variations in *night vision* ability in many cases can be traced back to seasonal variations in vitamins in the food. Vitamin deficiencies are not only caused by an alimentary deficiency but also by a

disturbance in the storage organ, the liver. An avitaminosis due to liver cirrhosis alters not only the threshold level but also the cone-rod transition time *(Haig, Hecht and Patek)*. An avitaminosis can be caused by diseases of the intestinal tract, e.g., when a diarrhea prevents a sufficient absorption of vitamins. Persons with exophthalmic goiter are, in general, more sensitive to light than average persons for the same reasons. *Albers and Sheard* (1936) found a more than 40 per cent increased glare-out value after thyroidectomy in comparison to the value before the operation. The absolute thresholds of persons with exophthalmos are frequently higher than normal, which is partly ascribed to a dysfunction of the liver and partly to a disturbance of the vitamin A metabolism. Night blindness linked with pregnancy could in some cases be explained by a vitamin A deficiency.

The *general diseases* and the *eye diseases* causing a disturbed night vision are compiled in the book of *Jayle, et al.* (pp. 174 to 300). It may be mentioned that high *myopia* can be associated with a slight decrease in night vision ability. The recovery after glare of high myopes is prolonged *(Hamburger)*. It is well known that *glaucoma* affects dark adaptation and that the absolute thresholds measured in a peripheral area are abnormally high in both portions of the dark adaptation curve, so that one must assume that the functions of both rods and cones are affected. *Houssin* found on 22 glaucomatous patients that central visual acuity was decreased for low luminances (also when it was normal or subnormal in photopic vision). The disturbances of night vision are a fairly early sign in primary glaucoma. Campimetry and perimetry in reduced light are useful methods in its detection. *Typical retinitis pigmentosa* can show a very restricted field but still normal dark adaptation curves when testing is made in the retained part of the field. Such cases would be subjectively so handicapped anyway that they probably would restrain from driving voluntarily. *Circumscribed choroiditis* may or may not affect night vision: it also may or may not be detected by a night vision tester depending upon which part of the retina was examined. An affection of the *transparency of the eye media*, e.g., a corneal dystrophy or a cataract need not affect the dark adaptation curve significantly. However, such persons would show a diminished ability to stand glare due to the Tyndall effect in their eye media.

On the basis of his own studies and following an evaluation of questionnaires and available literature, it would appear to *Danielson* (1959) that defects in the driver's peripheral field of vision are a minor cause of accidents, but he admits that further research is needed.

A *uniocular* person may have trouble in driving at night because

of the restricted peripheral field. It is also known that thresholds are lower binocularly than monocularly. An amblyopic eye would have a loss of adaptability. A person can have a diminished adaptability in one eye which has normal visual acuity equal to that of the other eye *(Pugh)*.

Night vision of aging persons.

The highest percentage of accidents occur in the age group of 25 to 44 years. But when considering the mileage driven by the different age groups it appears that the young drivers have the worst record and those in the 25-64 age bracket have the best record. The older drivers have again poorer records *(Allgaier,* 1957). *Richards* (1958) shows in his monograph in detail how the different visual functions diminish with age. The slight decrease of dark adaptation ability with age cannot be explained by a constriction of the pupil alone. It is partly due to the lower transparency of the eye media. The range of individual differences increases as indicated by the increased standard deviations of the absolute thresholds in old healthy persons with normal eyes *(Steven: Birren, Bick and Fox)*. *Luria* found that the individual precision of judgments does not deteriorate as the thresholds rise with age. In a statistical and mathematical evaluation, *Domey, McFarland and Chadwick* came to the conclusion that the rate of dark adaptation threshold decreases as a function of age. This is true for cones and rods, as follows from the 30 seconds and from the 6 minutes thresholds. *Bouma* (1947-48) found a decreased contrast sensitivity and diminished glare resistance in older persons. According to *Allgaier* (1958) glare resistance starts to diminish before 50 years of age and shows a more rapid falling off after 50. *Wolf* noticed that a sudden acceleration in sensitivity to glare occurs at about 40 years of age. *Sachsenweger* (see section III of present paper) noticed a steady decrease of stereoscopic acuity in mesopic vision with increasing age which he assumes is conditioned also by central factors. The decrease becomes pronounced in persons over 50. Other visual functions impaired with age are visual acuity, extent of the visual field, accommodation and speed of accommodation *(Allen)*. See also the summary about decreased vision with age by *McFarland and Domey*. Corrected aphakia does not deter most people from driving since the remaining central field of 30 to 40° seems to be adequate for safe driving, as follows from an interrogation of 130 aphakics by *Danielson*. Age is also a problem in old people since there is a higher frequency of general diseases and eye diseases causing impaired night vision. Although there is retardation of all sensory reflexes and a higher absorptive quality of the eye media it is very possible

that greater experience to some extent counteracts the decreased ability. In the age group over 65 the accident rate increases according to *Allgaiers* data since obviously the experience is outweighted by the physical shortcomings.

VI. GENERAL REQUIREMENT FOR A NIGHT VISION TESTER

As already stated, night vision is not synonymous with dark adaptation but implies a variety of visual functions: Static and dynamic discrimination of light and forms, of depth and distances, and of motion in foveal and peripheral vision often upon short exposure, low illumination or against glare or shortly after glare.

Since it is nearly impossible to incorporate all these functions into one routine testing procedure, a compromise should be made by omitting some of them. At first one would probably think about omitting testing of depth perception and of perception of motion. It follows from a survey by *Häkkinen* that judgment tests of speed and distance show a low reliability in experiments as they do in practice. The same refers to the reaction time. From the preceding one can deduce that a satisfactory test for night drivers should give information mainly about form perception in dim illumination, including testing of recovery from glare and also of glare resistance.

Following are some important points to consider when designing a night vision tester:

(1) The first and most important requirement for threshold testing is *constancy* of the light sources and easy checking of the *calibration*.

(2) A *preadaptation period* is necessary in order to eliminate or at least reduce the effects from various illumination levels encountered before the examination, although one could not eliminate the effect of a prolonged exposure to bright sunlight which can cause up to 50 per cent loss in night visual efficiency *(Clark, Johnson and Dreher; Peckham)*. Lenghtened sojourn in dark acts inversely.

Some authors recommend to start testing with a dark adaptation period of 15 to 30 minutes, or at least with a half an hour stay in a room of greatly reduced illumination. Wearing red goggles can substitute for part of the time in darkness *(Trendelenburg)*. Then follows the bright adaptation period. The field for bleaching should be large, since only then is constancy of the effect guaranteed. For limited luminance levels, e.g., 10 to 450 mL and exposure times of 0.1 to 4 minutes, time and intensity of preadaptation are interchangeable, which is in accordance with the Bunsen-Roscoe law $Ixt = \text{const.}$ *(Haig)*. Most authors found no further noticeable change in the dark adapta-

tion curve when the preadaptation lasted 10 minutes or longer. *Eckel* found an adaptation to about 0.2 stilb (628 mL) with natural pupils for 10 minutes sufficient, whereas a surface of about double the luminance caused disturbing entoptic phenomena. The authors agree also that one can compromise and shorten the preadaptation time to 3 minutes since the most drastic changes in sensitivity occur during these first three minutes. *Jayle and Ourgaud* conclude from literature studies that a complete adaptation would be obtained on 1500 to 2000 mL through a 2 mm. pupil within 3 minutes. The adaptation surface should be neutral white. The same source could be used as a glare source for studying recovery speed and glare resistance. It would be desirable to check whether the examinee has both eyes open while adapting to the bright light.

(3) The *distance of the target* should be standardized, in view of the fact that the pupil size and thus the retinal illumination would depend on the stimulus for accommodation. Figure 10 shows that in mesopic vision there is definitely accommodation possible, although its amplitude decreases with illumination. For fixational distances beyond 60 cm. the pupil would not change its size due to the near reflex as measured by *Luckiesh and Moss* (1937) at a luminance level of 0.1 mL.

(4) Although different *pupil diameters* would affect the result, it is preferable to test untrained persons with natural pupils and to consider a larger scatter of normal individual values than to use an artificial pupil. A correction for equal pupil size or expressing thresholds in trolands is not necessary except for scientific purposes. Different pupil diameters would cause different effects of preadaptation and also of glare. However, it would act correspondingly in common seeing.

(5) It should be considered whether or not to use a *fixation target*. Some authors prefer to investigate without a fixation spot since on dim illumination the observers would shift involuntarily from foveal to parafoveal vision. But this shifting includes a learning factor that increases the scatter of the data obtained *(Van Beuningen)*. For campimetry a fixation target is indispensable. A fixation target should be a dim red. The sensitivity for a special red is the same in rod and in cone vision, according to *Wald* it is a red around the wavelength 650 $m\mu$. It would not be advisable to test foveal vision only since persons with tunnel vision would escape attention: it would not be correct either to test a peripheral region only.

(6) One should decide whether to test *monocularly* or *binocularly*. Most authors agree that the final monocular absolute threshold

is higher than the binocular threshold by a factor of about 1.2. At the beginning of dark adaptation monocular and binocular thresholds show no significant difference when measured on a 10° centrally fixated field *(Schumacher)*. Using a test field of 0.67° *Crawford*, on the contrary, got a more rapid recovery in the first seconds after light adaptation, both for the foveal and parafoveal region, when tested binocularly rather than monocularly. The shape of the curve was not affected. Also, the glare-out intensity measured with the glarometer is higher binocularly than monocularly. That the binocular differential threshold is lower than the monocular was shown by *Crozier and Holway*. Besides these facts in routine testing of untrained persons a binocular observation would be preferable. It may be added that dark adaptation of one eye is not affected by the exposure of the other eye to field brightness up to 130 c/ft² *(Crawford)*.

(7) When designing the *size of the target* one should consider that with very small objects the intensity would be effective proportional to B x ω where ω is the solid angle subtended by the target at the pupil of the observer (Ricco's law). For progressively larger areas this spatial summation becomes progressively less complete until finally the luminance alone is responsible for the effect. For low luminances the limit of Ricco's law is higher than for high luminances.

(8) The best *colors* for target and background would be the achromatic neutral colors white, gray or black. Some authors prefer violet (purple) targets for testing absolute thresholds. However, violet is not adequate for visual acuity tests since it minimizes the distinctness of contours. Red is often used to test only cone adaptation. This would not be suitable for a special group of red-green deficient persons because they perceive red less intense than normals. *Schober* suggests yellow and orange-yellow for testing the macular region.

(9) A *limited exposure* of the target is desirable in view of the sometimes limited object exposures encountered in night driving. When shorter than 0.5″, the time should be standardized precisely in order not to get fluctuations of the results in accordance with the Bunsen-Roscoe (Blochs') law and its continuation, the Blondel and Rey law or Pieron's law (see *Le Grand*, p. 242). When testing a 2.3° area 7° above the macula *Yudkin* found no change in absolute thresholds due to exposure time variations operating over 0.5 sec. However, the scatter of values was least at 0.2 sec. flashes, which he explains by the following, that on a longer exposure the eyes are able to change fixation so that occasionally a more sensitive part of the retina may become stimulated. He concludes that a 0.2 second duration is the

most suitable for rod threshold stimuli. *Blackwell* (1955) chose a 0.03 second presentation as most adequate for application of his contrast threshold data in night driving situations. *Jayle, et al.*, (p. 366) recommend 1/3 sec. exposure of the target for testing dark adaptation. A prolonged constant fixation is not advisable since it causes phenomena due to *local adaptation*, usually resulting in a decrease of sensitivity.

(10) It is better to test the *appearance threshold* rather than the disappearance threshold since it is less subject to fluctuations.

(11) It should be possible to *check* the examinee's *answer*, e.g., when using a Landolt ring, by changing its position.

(12) Measurements of absolute thresholds and visual acuity in mesopic and scotopic vision show training effects to a large extent (*Rose*, p. 961). One should try to designate an examination procedure which requires a *minimum of training*. According to *van Beuningen* an apparatus for functional testing must not be too difficult but also not too easy. It must show a steady training effect not exceeding 15 to 25 per cent of the initial value with values constant after 4-5 days.

(13) The *range of variation* in a sufficiently large group from a mixed, untrained, healthy population should be known. It should be possible to separate with certainty persons with satisfactory night vision from those with doubtful or unsatisfactory vision, or to distinguish 3 groups: Normal, subnormal and night blind. The latter two types would then be submitted to a more elaborate examination.

(14) The *test-retest reliability* of the procedure must be high.

(15) The test should be of *moderate duration* in order not to overload the license bureau or test personnel and not to fatigue the examinee.

(16) The *method* should be *simple* so that persons with a minimum of preliminary training could administer it.

(17) The *apparatus* should not require too much space, possibly not require a dark room. It should not contain parts which in a series are difficult to manufacture alike, e.g., high precision lenses. The price should be reasonable.

VII. REVIEW OF NIGHT VISION TESTERS

The following review of night vision testers considers the illumination range encountered in driving and the features which allow one to test functions other than absolute thresholds. This review may not be complete; its main purpose is to show samples of the existing types of more or less suitable night vision testers.

The sole adaptometer, for testing *absolute thresholds* only, which

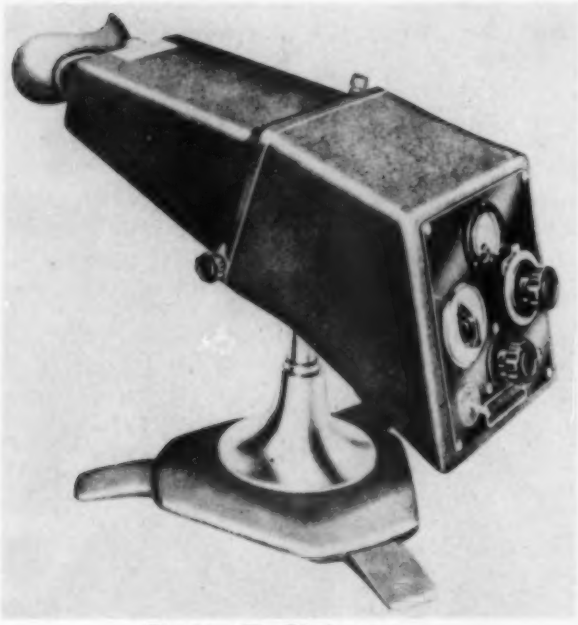

Fig. 14. The Biophotometer.

should be mentioned here is the *Biophotometer*, Figure 14, since it may be changed easily into an apparatus for form discrimination. It is an improved Birch-Hirschfeld adaptometer manufactured by the Bio-Medical Instrument Company, Chagrin Falls, Ohio. After a preadaptation period of ten minutes in darkness and three minutes to a moderately bright light source, the threshold for perception of 3 out of 5 patches of slightly different luminances is recorded in the first ten minutes of dark adaptation. The apparatus does not require a completely dark room. The reports about its value for detection of vitamin A deficiencies are equivocal but in the majority favorable.

The simplest devices for testing the recognition of forms are *charts* with *printed letters* or *numbers* presented at a standard illumination, e.g., the test by *Edmund and Møller*. It consists of 9 charts with letters at different contrast steps, illuminated by a 60 watt lamp. They are observed after 30 minutes dark adaptation through Tscherning glasses No. 8 to No. 1 of decreasing transmittance, allowing for each glass an adaptation time of 5 to 7 minutes. The letters require a visual acuity

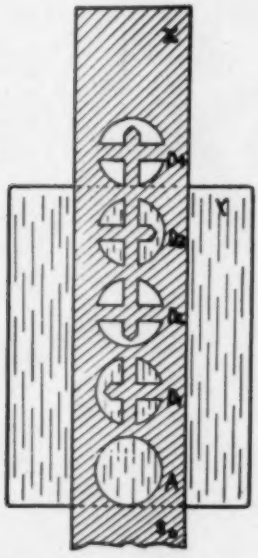

Fig. 15. Sketch of the supplementary target mechanism designed for use with the Hecht-Shlaer adaptometer. Window D2 showing the silhouette pointing down is opposite the opening in plate Y and ready for use as stimulus. (after *Miles.*)

of 6/36. Since the testing time of 70-80 minutes was too long, the authors constructed a small apparatus, the *scotopticometer*, with only 4 test types in 4 contrast steps and observed with Tscherning glass No. 4, requiring only a three minute adaptation time. However, the scotopticometer does not seem to be very sensitive.

A similar test which also can be regarded as make-shift is the *Luckiesh-Moss* (1939) *Low Contrast test chart*, a modified Snellen design in various degrees of contrasts with constant size, equivalent to a Snellen acuity of 20/140 when observed at 10 feet. The luminance of the background equals 0.01 ft-L, a value which occurs on road illumination at night. The observer adapts for 10 minutes to this luminance before the examination for his ability to recognize the letters.

To this group belongs also the test card by *Frederik* on which a dutch word is painted in different tints of gray and illuminated in steps of certain intensities. The time is noted at which different parts of the word become readable.

Simon mentions a comprehensive test chart used in Australia for drivers; it tests visual acuity, phorias, field of vision, color discrimina-

tion and dark adaptation, the tests being performed in from 2 to 3 minutes total time.

There is a group of adaptometers for testing form vision, for instance the *Feldman Adaptometer*, on which an arrow of dim standard luminance is presented below the field for purposes of light adaptation. The arrow is variable in its position. If, after 3 minutes light adaptation, the position of the arrow is recognized correctly in less than 5 minutes, normal dark adaptation is present. Forty per cent of clinical patients, tested with this apparatus showed a "dysadaptation." In the literature the test is recognized as being inexact.

The *Crookes Adaptometer*, used in England, can be supplied with an arrow on its 7 degree white target field. The arrow can be rotated in four directions and can be shown at definite steps of background luminance. The time is noted at each step when the position of the arrow is perceived correctly *(Godding)*.

Similarly, *W. R. Miles* suggested a modification of the *Hecht-Shlaer Adaptometer* by using a slide with 4 different positions of a cross with one short arm and a fifth figure of a plain circle, all 5 figures fitted to be inserted in front of the 3 degree target window, Figure 15. After a preadaptation to 1500 mL for 3.5 to 5 minutes, at certain time intervals the flashed illumination of the window is increased in steps sufficient for a response during the dark adaptation procedure.

The same principle is applied in the *Nylund Adaptometer*, where a black Snellen hook 5 cm. in height is used as target and the luminance thresholds are determined at which its position can be recognized correctly.

A universal instrument, very elaborate in its construction is the *Goldmann-Weekers Adaptometer* of the firm Haag-Streit, Berne, Switzerland, Figure 16. It consists of a half sphere for preadaptation and is set up with interchangeable test objects. Landolt rings are used with 100% contrast, requiring a visual acuity of 0.025, or gratings with 10%, 20%, and 100% contrast corresponding to visual acuities from 0.1 to 0.6. The targets appear at 50 cm. distance and are shown in intermittent illumination. The intensity is raised until the target is perceived. The recording system is very convenient. The following functions can be determined monocularly and binocularly: (1) the absolute threshold of perception in the course of dark adaptation (a) of a particular part of the retina (b) of the whole retina, i.e., integral adaptation, (2) the adaptation of the cone apparatus in the region of the macula, the periphery and the whole retina, (3) the threshold of perception during dark adaptation by the Rieken method

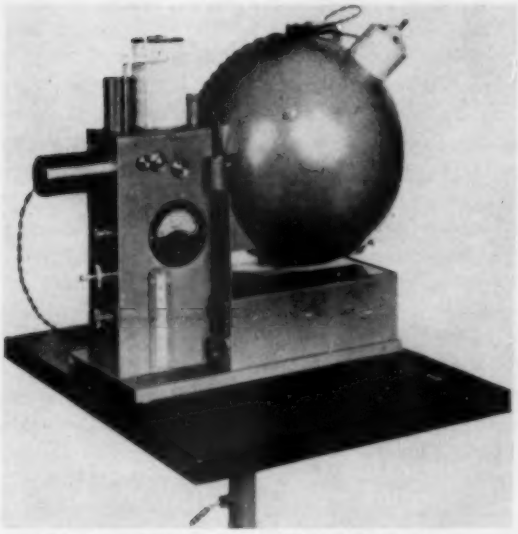

Fig. 16. The Goldmann-Weekers Adaptometer.

(see later), (4) visual acuity during dark adaptation: (a) Comberg's Nyctometer principle (see later), (b) glare resistance, (c) visual acuity of the completely dark adapted eye, (5) the differential threshold *(Goldmann; Fankhauser)*.

An apparatus for exploration of several visual functions is the *Jayle-Blet Light Sense Tester* (See *Jayle, et al.*) or Adapto-perimeter which enables one to examine visual fields, dark adaptation, and flicker-frequency, all on variable backgrounds and with objects of variable luminance.

Schober's Adaptometer (Schober and Gunther) allows one to measure absolute thresholds, differential thresholds, Ricco's limiting angle and visual acuity, not only on continuous but also on short exposures. An investigation of 300 persons revealed that the deficiency in one of these functions does not necessarily mean a deficiency in another one.

Della Casa's Adaptometer is an apparatus especially designed for motorists. *Della Casa* tried to stay close to the requirements for night drivers; however, he had to compromise in order not to make the apparatus too expensive. The apparatus consists of a cylindrical tube, 25 cm. in diameter, 38 cm. in length, painted matt white inside and

illuminated by a tube in its whole length through an adjustable slit at its top. When the slit is fully open, the cylinder is ready for light adaptation. By cutting down the width of the slit, low illumination is obtained. At the rear wall of the cylinder is a disk which permits a rotation of a Landolt ring of low contrast. From 40 cm. distance the break in the ring requires a visual acuity of 0.01. In order to be independent of a dark room a hood of black cloth is fastened to the anterior wall of the cylinder but not used during bright adaptation. The test starts with a bright adaptation to 740 Hasb (74 mL) for 10 minutes. After the bright adaptation the head is arranged in the hood. The cylinder is set on a luminance of 0.05 Hasb (0.005 mL). The time is checked when the examinee first perceives the disk, then when he perceives the Landolt ring and finally when he recognizes the position of the gap which is checked three times. The results can be plotted on a graph with the time as abscissa, the different items designated by the numbers 1, 2, and 3 on the ordinate, Figure 17. Persons with normal night vision perceive the disk after 6 to 10 seconds, the ring after 30 seconds, the 3 different positions of the break correctly after less than 4 minutes. A person who needs more than 4 minutes has doubtful night vision, a person requiring more than 6 minutes has a delayed dark adaptation and must be sent to a specialist. When a person recognizes not more than one position of the break correctly within 10 minutes, he is not fit for night driving. *Della Casa* expected that his apparatus would be introduced for routine testing of motorists, but up to the present time a night vision examination is not mandatory in Switzerland, except for bus and truck drivers. The apparatus is used with good results by Swiss Air for testing pilots.

A method which may give an idea for an adequate night vision tester is the objective adaptometry by *Rieken*. He used a pattern of

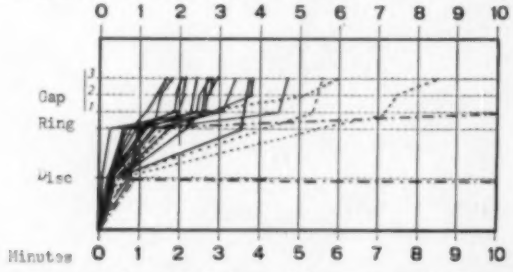

Fig. 17. Recording of results on *Della Casa's* Adaptometer. Solid line = persons with normal dark adaptation; dash line = persons with delayed dark adaptation; dot and dash line = persons not fit for night driving.

black and white stripes revolving in front of one eye and dimly illuminated in steps of increasing intensity until a nystagmus appeared. The latter was observed through a corneal microscope focused on the sclera of the other eye. *Rieken* found a smaller scatter of values with this method than when measuring subjective absolute thresholds. The method was improved by *Meesmann* in collaboration with the firm Zeiss, by introducing a projection of wandering stripes by means of a spiral stripe pattern on a rotating disk. After *Jonkers* had established the best width for the stripes and the most appropriate angular speed. *Jonkers and Jongbloed* combined the *Rieken* method with the *Goldmann-Weekers* adaptometer. However, they retransformed the method into a subjective one insofar as the subjects had to push a button as soon as he perceived the moving bars. This was recorded automatically by a writer.

It has been tried also to combine Rieken's method with an objective registration of the nystagmus. However, that would require a more expensive and elaborate apparatus which can probably not be used as a routine method.

Instruments have also been devised to test *glare resistance* and *recovery from glare* in the first seconds and minutes after extinction of the glare source.

A simple apparatus to test recovery within the first seconds has been designed by *Pett;* it consists of a black box, one cubic foot in volume, containing a white surface 12 inches square which reflects the light for preadaptation. The illumination at the eyes then is 50 ft-c. After 30 seconds of light adaptation 2 rectangles, dimly illuminated from behind, one horizontal, the other vertical are shown one at a time. The time is recorded when the person perceives the bars correctly. The normal value is 10 seconds or less. A time over 15 seconds means deficiency. Of 1600 persons tested in Alberta, Canada, 52 per cent were found deficient in vitamin A. The test does not appear to be very sensitive. Since there are two possibilities only, a failing or passing by chance is very probable.

A still simpler device has been described by *Whiteside;* a matt black card of diffuse reflectance of 3.8 per cent with a rotatable letter T of low contrast is observed from 60 cm. distance. The time is recorded at which the observer is able to make out the complete outline of the T from the moment of cessation of a one minute adaptation to the sky. The usual recovery time is 20 seconds. The card was designed to be mounted on the bottom of the instrument panel of airplanes in order to test pilots during flights.

Albers and Sheard (1936a) describe a *glarometer* of the Glarometer Co., Chicago, Illinois. Its sole function is to measure the resistance to glare by measuring the intensity of illumination in central vision which, when increased slowly, finally makes it impossible to see the letters on a target of given illumination. The glare-out amount was found to be higher binocularly than monocularly and for the right eye higher than for the left eye.

An apparatus which measures the recovery of *visual acuity* in the first 2 minutes and also the glare resistance, is the *Nyktometer by Comberg* (firm Zeiss), Figure 18. It tests binocularly foveal and parafoveal visual acuity within the first 2 minutes after adapting to a white surface of 3000 asb (300 mL) for 3 minutes. The target is a small visual acuity chart appearing at 25 cm. distance, black letters on a white background. The letter charts can be easily varied. There are 4 possibilities for changing the luminance of these charts. The usual testing luminance is 0.5 asb (0.05 mL). The normal visual acuity on a test chart luminance of 0.05 mL after 2 minutes recovery from the preadaptation is 0.4 to 0.55. Individual fluctuations are from 0.1 to 0.2 visual acuity units (*Rose*, p. 946). The visual acuity can also be checked while a peripheral glare source stays on, without time control. When the background of the letter chart has a luminance of 4 asb (0.4 mL) a normal visual acuity value with the glare source on is 0.55.

The *Nyktotest* developed by *Schober* (1956) in cooperation with

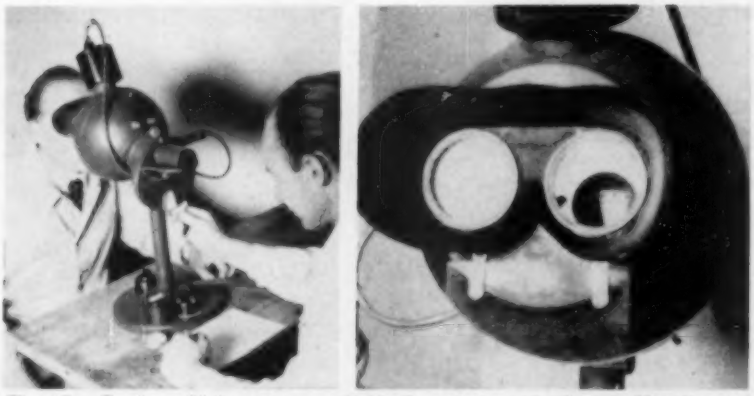

Fig. 18. Combergs Nyktometer. a. (left) General view. b. (right) Visual acuity test chart, which during bright adaptation is covered by a white flap. When used it is illuminated from rear. (from "German Aviation Medicine, World War II, Vol. II.")

the firm Rodenstock in Munich, Germany, was devised to replace the Comberg Nyktometer which is now not available. Similarly it contains an integrating sphere for light adaptation, the luminance of the latter being 2000 asb (200 mL). The preadaptation time can be set from 1 to 10 minutes. As soon as the preadaptation light vanishes the test charts appear automatically in intervals of 10 seconds, 12 charts all together, each exposed for 1.6 seconds. Since they appear at infinity the examinees must wear their distance corrections. The luminance of the charts equals 0.1 asb (0.01 mL) with the idea that luminances of objects illuminated by the headlights of cars at the minimal distance necessary for recognition of an obstacle are similar to this value. The targets are the checkerboard pattern by *Goldmann* with white circles instead of squares on a black background, Figure 19. The problem is to indicate which of the 4 squares is different from the others. This question is easier to answer than the one about which of the gratings is the coarser one. At any time the light for bright adaptation can be administered again in order to check a glare effect. If during the first two minutes 11 or 12 test patterns are perceived correctly the "immediate recovery" of the examinee is sufficient. If he perceives 8 to 10 patterns only, then the test must be repeated. If less than 8 patterns, the examinee must be referred to a specialist.

The *night sight meter* of the American Automobile Association consists of a light proof case 32 inches long. In addition to an eyepiece a black hood keeps out extraneous light. The test targets are Landolt

Fig. 19. Checkerboard pattern by *Goldmann*, used in *Schober's* Nyktotest.

rings requiring a visual acuity of 20/300. Fifteen rings are mounted on the circumference of a white disk. They appear at the rate of 45 per minute. The illumination of the circle can be varied from 0 to about 0.035 ft-c. A glare source, consisting of two 6 watt lamps, the center of which makes an angle of 9° with the line of sight of the observer, produces at the eye about 1 ft-c. That corresponds to about the maximal glare one meets on the highway from an oncoming car at a 2 lane highway at 150 feet distance. With the glare sources on, the subject tries to identify the break in each circle as it appears. The illumination of the circles is gradually reduced until the subject cannot longer identify the breaks. The test is repeated three times. The following test is that for *vision in dim light*. The glare test obviously serves as preadaptation. Three readings are obtained in the same manner. A third test, for recovery after glare starts with an identification of the rings set at maximum brightness and with the glare lights on. Then after this exposure to glare (the duration has not been stated) the glare lights are turned off and the illumination of the targets reduced to the average needed in dim light. The time which is required to see these targets is recorded. Testing results of nearly 500 men and about 800 women had an unexpected high test-retest reliability. A training effect seemed not to be significant (*Allgaier*, 1958). The high test-retest reliability seems amazing in view of the fact that there is no standardization of the preadaptation and also not of the time of testing "vision in dim light" (see section VI of present paper dealing with requirements).

Sloan (1939) emphasizes the investigation of the whole peripheral field at least in one horizontal meridian. She devised an instrument to be used in connection with the Ferree-Rand perimeter. It consists essentially of a fixation device and an attachment of variable luminance which can be mounted at any desired point on the arc of the perimeter. Its size is variable between 1 and 4 degrees. It can also be used to test visual acuity. A campimeter for low luminances has been described by *Lister-Sharpley* (cited by Jayle, Ourgaud, etc., p. 381). *Jayle* and *Blet* use a Bjerrum screen with white spheres as targets for testing in mesopic and scotopic ranges. *Harms* designed a large half sphere adjustable between 1 and 1000 asb (.93 to 93 ft-L) with small projected targets of variable luminance. The method of *Weekers* and *Roussel* for measuring the enlargement of the visual field in one meridian during dark adaptation has been described on page 303. *Danielson* found the *Harrington-Flocks* Multiple Pattern method useful for a quick screening of the central fields of drivers. It may be added that the persons

failing this test should be further examined since persons with small local defects may be adapted for night driving. In general, campimetry requires time and therefore may not be the method we are looking for. Besides if not combined with form vision, it does not give the information about the most important night vision function.

Apparatus with *moving silhouettes* of airplanes or landscapes against a background of low luminance, simulating an overcast night sky, have been used for the training of night vision in the Air Force during and after the war, e.g., the night vision trainer by *Pinson*, *Chapanis* and *Schachter*. Another projection method for training night vision has been described by *Perdriel* a.o.

A *cinematographic* technique is used by *Jayle* for classification purposes. A film of progressively increasing luminance is projected on a screen with a reflectance of 0.8. The subject is completely dark adapted. The following four thresholds can be established: (1) a cinematographic light threshold, which agrees with those found by other adaptometric methods, (2) a cinematographic differential threshold, when a distinction of more or less bright areas on the screen is possible, (3) a cinematographic elementary morphologic threshold, the recognition of gross forms, animals, etc., (4) a cinematographic identification threshold, when an exact recognition of different elements of the picture is possible. Since it is impossible to measure the exact luminance of a picture, the normal thresholds must be defined by the results on 100 to 200 normals. Persons with good adaptation values can have bad morphologic or identification thresholds or one with bad adaptometric data can have good morphologic or identification thresholds.

VIII. CONCLUSIONS:

It has been shown that the night vision of drivers comprises a great variety of visual functions. Since the correlations are not very significant it is not advisable to make conclusions from one function about another one. On the other hand, it is impossible to incorporate the whole complex into one routine examination. Therefore, only those eye activities should be considered that appear of primary importance in night driving. Since the correlation between the activity of the cones and the rods is not very high, testing should be done exactly at the illumination levels corresponding to the driving situation at night. It appears that an adequate night vision tester for drivers should test dynamic (and static on short exposure) form perception in foveal and peripheral vision in the range of mesopic vision. There should also be provision for testing immediate recovery after glare and also probably glare resistance.

A review of the existing instruments shows that there is no apparatus available which would correspond exactly to the requirements. Some are too restricted by testing only one limited feature: others are too elaborate for a routine screening. But the knowledge about these constructions, to recall for instance the Goldmann-Weekers adaptometer in combination with Rieken's method or the projection trainers of the U. S. Air Force, may give some idea of a new and more satisfactory design. The knowledge about the normal ranges of the visual functions as reviewed in section III of this paper may be helpful.

In view of the fact that night vision deficiencies are not infrequent, a regular testing of night vision ability of drivers would be desirable and as soon as a suitable examination method has been developed, one can say that testing of night drivers will be feasible.

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CONTACT LENSES DO NOT BELONG IN THE MARKET PLACE

In the early days of modern contact lens practice (only a few short years ago), some practitioners regarded the patient's ability to wear the lenses all day as the main criterion of a good fit. More recently, however, a sounder basis for evaluation has become almost universally adopted.

Two authors whose writings appeared in 1961 may be cited as exemplifying this safer trend. Pheiffer* describes a good contact lens fit as one in which there is ". . . no subjective or objective symptoms, and no corneal involvement ascertainable with the biomicroscope."

Player** describes the present time as "a period of re-evaluation, a settling down, a gathering of forces." He then goes on to give ex-

*Pheiffer, Chester H., The contact lens characteristics for an optimal fit, J. Am. Optom. Assn., 32 (6): 451-452, 1961.
**Player, Herbert S., The contact lens field—a time for re-evaluation, Optom. Weekly, 52 (4): 167-169, 1961.

amples of some of the advice which should be offered the patient. Some of these instructions follow:

> Observe professional advice in regard to hygiene, insertion, removal, wetting, and storage of lenses.
>
> Never endure discomfort or blurred vision. Remove the offending lens, cleanse it and reinsert. If the problem continues, remove the lens and seek professional advice.
>
> Do not wear lenses irregularly from day to day, or sleep with lenses on.
>
> If illness or other reasons cause the discontinuance of lenses, start again on a limited schedule building wearing time gradually.
>
> Carry a card in your wallet or purse, stating that contact lenses are worn and advising their removal in case of emergency.
>
> Have a pair of eyeglasses ready for use when contact lenses are not worn.
>
> Make sure that eyes and lenses are examined every few months.

It is apparent from these quotations that optometrists are reconciling themselves and their patients to approach contact lenses with caution. The patient must be reconciled to having the lenses and his eyes checked every few months. He must be prepared to have the lenses refitted if change occurs. The patient must be prepared to discard the lenses when he is ill. He must be reconciled to the need for wearing regular spectacles some of the time. Finally, he must be psychologically ready to discard the lenses completely if there is indication of corneal damage.

Most important in this new thinking is the emphasis upon the physiological integrity of the cornea. A good fitting pair of lenses is more than one which produces no subjective discomfort. The cornea must be examined regularly and its health assessed. The biomicroscope must be used in this evaluation. The keratometer should be used to determine whether the lenses are producing any marked changes in curvature. Other subjective and objective procedures will be used, each designed to demonstrate whether the lenses are being worn *safely* as well as comfortably.

With this new concept a sharper delineation between professional and commercial outlook will become apparent. So long as patient comfort was the sole criterion of a well fitting pair of contact lenses, these could perhaps be sold as a commodity. Advertisements could promise a single fee for life, could prey upon patients' desire to rid themselves of spectacles, could promise one day service, and could guarantee "satisfaction."

Contact lenses are such that the patient may be easily satisfied . . . at least, initially. So long as patient comfort was all that was desired, lenses could be fitted by commercial optometrists and opticians, hypnotists, yogi experts, and sewing machine salesmen turned contact lens fitters. Any of these could fabricate or purchase for the patient a pair of lenses which could give acceptable vision and little discomfort.

But this is not all there is to fitting contact lenses. The patients' future vision must be safeguarded. With a renewed emphasis on the principles of good corneal physiology and constant re-evaluation necessary, it becomes increasingly clear that contact lenses do not belong in the market place. The need for time, experience, judgment, and advice (those essentials which the professional optometrist has for sale), make this so.

The contact lens wearer, if he is to be assured of no harmful effects must buy more than a pair of contact lenses with a lifetime guarantee. He must assure himself of a continuing service of repeated examinations, careful observation for possible corneal change, constant advice on changes and how to alter his status in relation to these changes. He needs the continuing optometrist-patient relationship found only in professional offices.

MONROE J. HIRSCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

THE ACADEMY AND ITS PROGRAM*

Stephen C. Outlaw†
Albany, Georgia

Two dairy cows stood under a tree chewing their cuds. They spoke of the problems of pleasing human beings—and it left them somewhat depressed. At that moment a big milk truck passed bearing on its polished white surface the words "Fresh Milk—Pasteurized—Homogenized—Vitamin A Added." The older cow looked at the younger and said "Makes a body feel right inadequate, doesn't it."

I am here today somewhat in the same position as the cow—with a feeling of inadequacy, wondering what I can say to men in a state where Optometry has not only had Vitamin A added, but many of the others—including the growth vitamins and energy vitamins as well.

A talk presented before the Florida Chapter, American Academy of Optometry. Submitted on May 20, 1961, for publication in the June, 1961, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Optometrist. Fellow, American Academy of Optometry.

We in the Southeast look up to our sister state of Florida, perhaps at times with a tinge of envy, for you have achieved many of the things we are still striving for. To us Florida is more than a land of sunshine, orange juice and luxurious ocean front hotels. When we think of Florida we think of clean Optometry, aggressive Optometry—Optometry on the move. You have set the pace in the Southeast for optometric legislation, optometric education—and perhaps most of all, optometric enthusiasm.

My courtship with your state has extended over a period of more than 30 years. I took the Florida Board in 1928 and a year or two later I attended one of your conventions right up the beach at Hollywood before I had even attended one in my own state. There I made warm friendships that I have cherished throughout my optometric career—Carl Eychaner, Jiggs Ingram, Tom Moore, Bill Davie, Steve Hill, Jack Bumpous, Art Kitchen and others. Many of these architects of our profession have gone to their reward, but new and vigorous personalities have risen to take their places. The caliber of these men is attested by the lofty position your profession occupies.

And now with the election of Judd Chapman to a trusteeship in the A.O.A., Florida will have a strong voice in national affairs. Knowing Judd as I do, I predict that it is only a matter of a very few years before Florida can lay claim to the highest office in Optometry. We in Georgia share your pride in Judd for we claim him as an associate member of our State Association.

I saw Judd in Atlanta at the Southern Council in February. I ran into him one day in one of the large department stores where he was admiring an oil painting. Not knowing that Judd's tastes ran to the arts I took a closer look. He had in his hands one of these modern, abstract paintings that defies description. As I watched he turned it sideways, upside down and backwards—it looked the same in any position. To my amazement, Judd said to the salesman, "I'll buy this one." I walked over and said, "Judd, why do you want to buy that thing? You can't tell heads or tails about it." He said, "I know it but I still want it. It's the best damn picture of optometric situation I ever saw."

It is my privilege to bring you greetings from Dr. Ralph Wick, president of the American Academy of Optometry. Now, he didn't send me down here. After he found out I was coming anyway, he asked that I express his deep appreciation to you for the tremendous interest and enthusiasm your Florida chapter is showing. He is particularly

pleased with the some eight or ten new members added to your chapter during the last year. President Wick is eagerly looking forward to bringing you his own personal greetings when the Academy holds its annual meeting here in December, 1962. You should have seen Jack and Art and the others from Florida working at the annual meeting in Chicago in 1959 trying to get the convention for Miami Beach. They were passing out orange juice right and left. That's the first time I ever knew that Florida orange juice was aged in the wood for six years before you served it.

Since this is an academy luncheon and it's a subject close to my heart, let's talk about the Academy for a few minutes. I'm assuming that in addition to your chapter members, there are others here who are potential members. And let me add here, this is no sales pitch. The Academy has never conducted a membership drive. I simply wish to point some of the practical advantages of being a Fellow in the Academy in addition to the honor attached thereto.

I like President Wick's definition of the Academy: "An international organization of research men, teachers and practicing optometrists joined together to promote the highest standards of professional conduct in the practice of Optometry and to stimulate research and education by providing a common meeting ground of Fellows with similar interests."

The ideals inherent in the Academy Standards of Practice have in the past set the pattern and established the goals for optometric conduct. For this reason, up until the last decade a relatively small percentage of optometrists were eligible for Academy membership. However, either through legislation, or the voluntary elevation of professional standards, the majority of optometrists in most areas can qualify for membership on the basis of standards of practice alone.

This has been reflected in our membership growth. We have shown a steady, solid growth and at the moment membership is over one thousand.

There are two completely diverse opinions regarding requirements for membership in the Academy. One group feels that all you have to do is meet the requirements and pay the dues and you're in. While on the other hand there are those who think the requirements are so high they can never attain them. Both, of course, are erroneous. The Academy standards are such that they do present a challenge to those seeking admittance. But what's wrong with that? Everything worthwhile man has ever achieved has initially presented a challenge.

And then occasionally we hear men say, "I would like to be a Fellow of the Academy but I just can't be bothered with making out those ten case reports and submitting to a practical examination." Obviously a person who is so unwilling to face a challenge is certainly incompatible with the goals and ideals the Academy has set for itself.

I had occasion not long ago to congratulate a friend in another profession on being elected a Fellow in his Academy. He told me he spent more than a year preparing his case reports—and he was proud of it!

The Academy has no ambition to be a big organization—as such. The esprit de corps on which it prides itself would be lost in the sheer weight of numbers. However, we do seek a continued, strong, vital growth based on a careful selection of the very best men in our profession. The Academy does not consider itself a rival or in competition with other optometric organizations. Although it is organizationally entirely independent of the American Optometric Association, it feels that it is complimentary and supplementary to it. All applicants to the Academy within the United States are required to hold membership in the A.O.A. at the time of admittance to the Academy.

There's a further challenge that presents itself to the membership. I'm referring to attendance at the annual meetings. Your membership has not run full cycle until you have attended one of these meetings. And if you've attended one, you'll want to go back. They are the very heart—the life blood of the Academy. If you're interested only in politics, don't go—there's very little of that. Almost the entire emphasis is placed on the educational program. In fact, it is the principal excuse for getting together, and the standard of excellence of the program sets the pattern of the Academy itself. The clinical side of Optometry is stressed—yet a glimpse into the future is often provided by the men who are doing the research in our profession. An opportunity is provided to hear the reports of the most recent projects in the schools, in industry and government before they appear in print.

Perhaps the greatest opportunity at these annual meetings is to talk individually with all the leaders in the various fields about the problems which we may have in ceratin areas of our practice. These men are not only willing but glad to discuss in detail any questions any of us have. I know from my own personal experience that there is an esprit de corps at the Academy sessions unrivaled by any other similar type meetings.

We meet on a common ground, with common interests and speak

a common language. And speaking a common language is quite important, not only among optometrists but also in a doctor-patient relationship.

I heard of a case not long ago in which a patient misunderstood his doctor's directions. It seems that this gent who was getting on in years went to his physician for a checkup. The doctor examined him, gave him a prescription to be filled and told him to be careful and return in 30 days.

Six months went by and the patient failed to return. The doctor met him on the street one day and inquired as to the state of his health. The man said, "Doc, I never felt better. That advice you gave me was wonderful and I'm having the time of my life." The doctor said, "I gave you a prescription to take but I gave you no advice." "Oh, yes, you did," the patient replied. "You told me to get a hot mama and be careful." "The hell I did," the doctor said. "I told you you got a heart murmur and be careful."

When Dr. Richard Schiller was elected president of the American Optometric Association last year he chose as the theme of his program "Broaden Our Optometric Horizon." Let me tell you how the Academy has not only fallen in step with this theme but was working toward it long before Dr. Schiller's pronouncement.

In 1956 the Academy's Executive Council conceived the idea of presenting a three day post graduate course prior to the Annual meeting of the Academy. Unlike the annual meetings, non-Academy members would be permitted to attend these courses. It was felt there were many men who would like to take brief refresher courses in certain phases of their practice in which they were already engaged—or perhaps a longer course in some technique they wish to add to their practice. A rather ambitious program of forty-two courses was set up ranging in length from two to twelve hours.

The program met with instantaneous response. Each succeeding year showed not only an increase in the number of courses but also a comparable increase in the number of registrants. In San Francisco last December there were seventy-five courses with a total of 188 hours of instruction. Fellows, it is literally an optometric "cafeteria." Of course, no one could take them all for some of them run concurrently. But suppose, let's say, you wanted to brush up on your technique of charting fields. You could probably pick that up in a two hour course. On the other hand, an advanced course in contact lenses might require twelve hours. I took one two hour course just to learn how to pronounce it.

I know of nothing that is doing more to "Broaden Our Optometric Horizon" than these courses—combined with the papers presented at the Annual Academy meetings. Every optometric college and university is represented on the staff of instructors at these meetings.

Another field in which the Academy has pioneered is Geriatrics—the care of the vision of the aging. This should be of particular interest to you here in Florida. During the last decade the nation's population as a whole increased 18½ %. But the over 65 age group increased 34½ %. There are now 16½ million in this age bracket—and it looks like all of them want to come to Florida.

One of the most authoritative guides to the visual care of the aging patient has recently been authored by two Academy members, Drs. Ralph Wick and Monroe Hirsch. Much of the material in this book was originally presented at Academy meetings. It wouldn't at all surprise me if a section on Geriatrics was added to the Academy at some future time.

Why am I telling you all this? Perhaps I'm like the young preacher who had his first call to a little country church. Someone asked one of the deacons how he liked the new preacher. The deacon said, "Well, he ain't got much education and he can't preach worth a hoot; but he sure does know how to brag on the Lord."

But it's more than bragging on my part. I tell you this because if you are an Academy member and have not availed yourself of the many educational facilities the Academy has to offer, I want you to know what you are missing. If you are a prospective member I think you should know the pride we who are members share in our Fellowship.

With all the Academy has to offer, combined with all that Florida has to offer, I predict with confidence that the 1962 meeting right here in this hotel will be the biggest in the Academy's history. And nothing would please me more than to see a strong, vigorous and active Florida Chapter on hand to show the Academy Fellows from all over the United States and Canada just what Florida can do.

But that is eighteen months away. In a little less than seven months the 1961 meeting will be held in Chicago. Attend that—and get a preview of what's coming here the following year. I believe it was Longfellow who said:

"The heights by great men, reached and kept,
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night."

In the Academy, we have those who have reached the heights—who occupy lofty positions in the profession. And there are those of us still toiling upward in our quest for knowledge and attainment of professional ideals. But it bespeaks the spirit of the Academy that those on top are ever willing to reach down and give a hand—share their knowledge and guidance with those of us still toiling upward.

And when Academy fellows get together there is no high ground —no low ground—only a group of men with similar professional ideals, bound together by their mutual search for better ways to care for human vision.

On the wall of my examination room hangs a certificate stating that I am a Fellow in the American Academy of Optometry. It is placed so that I see it each time I enter.

Now the mere embossing of my name on a piece of parchment does not, in itself, make me a better optometrist. However, the fact that I have been accepted by a group whose organization embodies the highest ideals in our profession causes me to strive very hard to live up to those ideals and to serve my fellowman in the professional capacity the Academy has a right to expect of me.

If enough men catch the spirit and meet the challenge offered by the Academy, then truly Optometry will achieve its rightful place in the sun.

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MICHIGAN CHAPTER MEETING AT EAST LANSING

The Michigan Chapter of the Academy holds two meetings a year. One in the Spring and one in the Fall at the University's Kellogg Center for Continuing Education. Morning speakers are drawn from the teaching and research faculty of the various colleges within the University.

The morning session this year was conducted by Owen D. Brainard, assistant professor of the Department of Art. He spoke on "Envisioning Art." The lecture was illustrated with beautiful color slides of various types of artistic expression through the centuries, and particularly into the modern paintings. The afternoon session was conducted by Dr. Phillip Haynes. He spoke on "An Evaluation of the Newer Concepts in Contact Lens Practice." This session ran from

1:30 to 6:00 P. M. Dr. Haynes covered theoretical and clinical contact lens developments.

The Michigan Academy program has included in its cultural series "Building a Reading Program Upon Good Literature" presented by Dr. Joseph Druse and "Developing an Appreciation for Good Music" by Charles McDermid of the Music Department.

PAUL L. CONNOLLY

1148 S. WOODWARD
ROYAL OAK, MICHIGAN

CORRESPONDENCE

CONTACT LENSES AT BODY TEMPERATURE

To the Editor:—

While studying under Dr. Neal J. Bailey at Indiana University during the summer of 1958 we were informed that Corneal Tonometry could be successfully done by an Optometrist without drugs and without pain. That, as we could easily demonstrate, the cornea was not sensitive to pressure, but was sensitive to the cold metal of the tonometer, when in contact with the cornea; and that by merely bringing the instrument to body temperature, the patient was not aware of pain.

Upon entering the contact lens field, I found that the profuse watering, experienced by most patients, upon the first insertion of their contact lenses could be avoided. Again, reasoning that if the cornea was not sensitive to pressure and the slight bit the upper lid had to stretch to accommodate the thickness of the lens could not cause the watering, and that as we were aware, the watering ceased after a period of time: I decided to bring the contact lens up to body temperature before insertion. Time after time I have demonstrated to my own satisfaction that the tearing could be eliminated by this simple procedure. I have asked my patients to keep my little secret and have waited to tell of my experiences until after many patients have proven the point. I have, of course, explained to each patient before inserting their contact lenses, the cause, in my opinion, of the tearing that others were experiencing and that they could be assured that they would have no tearing if the lenses were first brought up to body temperature.

I personally feel that if this information is made known to the public that one of the drawbacks of patient acceptance of contact lenses will be eliminated. Thus we will bring to a close the "Crying Towel and Bawl Room" era.

Procedure: Before inserting, dip lenses into water slightly warmer than body temperature for a few seconds so that by the time they are inserted they will be at body temperature. Then have the patient look down at about forty-five degrees for a few moments until the upper lid adjusts to the lens before raising the eyes and looking about.

W. BURNLEY STEPHENS, O.D.

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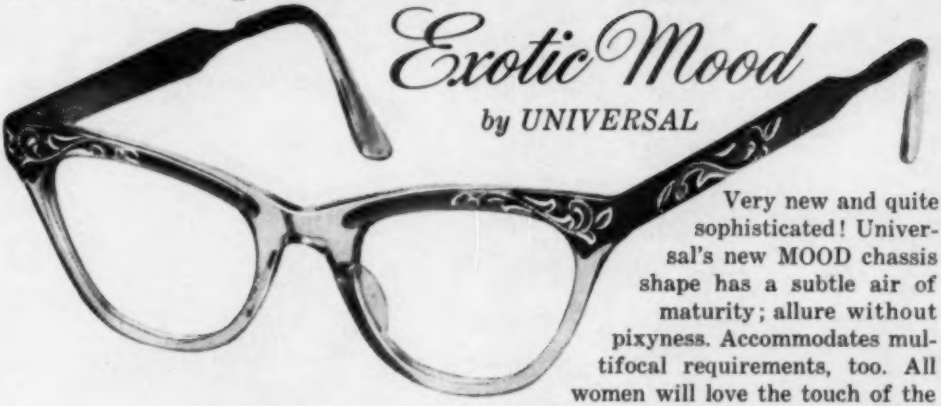

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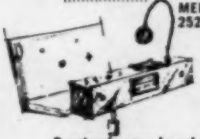

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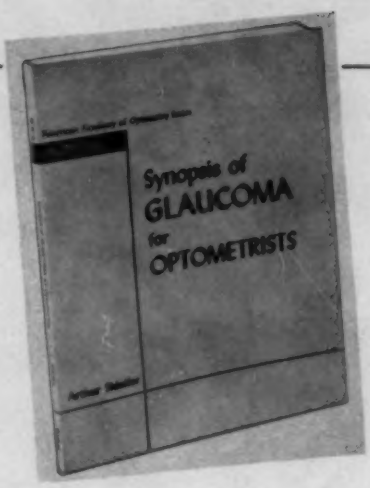

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Usable for both the practicing optometrist and in the classroom, this book is the first in a series of home study courses, published by the American Academy of Optometry, intended to round out its work in postgraduate education. The author is a practitioner as well as an educator. His work covers etiology, clinical signs, symptoms and screening tests used to facilitate the understanding of glaucoma detection and referral.

The subject matter is designed to present the noticeable features of glaucoma to facilitate detection by the optometrist, and subsequent referral to an ophthalmologist.

In addition to this information, all aspects of the disease are covered so that the optometrist will be familiar with procedures used by the ophthalmologist in treating cases which he has referred.

Now in its second printing, Synopsis of Glaucoma for Optometrists is being used in a number of postgraduate study courses. Optical distributors and manufacturers of ophthalmic supplies throughout the country have been successfully selling the book.

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